**The Boeing Company**
P.O. Box 3707
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July 29, 2014
9L-22-N410-BA-101

**BY EMAIL AND HAND DELIVERED**

Melissa Blankenship
U.S. Environmental Protection Agency
1200 Sixth Avenue, Suite 900, AWT-121
Seattle, Washington 98101

Subject: 2-10 Sheetpile Interim Measures (IM) Optimization Work Plan;
AOC 2-10.3A & AOC 2-10.4A, Resubmittal
Boeing Plant 2, Seattle/Tukwila, Washington
EPA ID No. WAD 00925 6819
RCRA Docket No. 1092-01-22-3008(h)

Dear Ms. Blankenship:

Please find enclosed four (4) copies (each with an attached CD copy) of the subject Work Plan revised in a manner we believe fully addresses your comments dated June 11, 2014. Note that a CD copy is also being provided to Mr. Hideo Fujita.

We appreciate the opportunity to have discussed EPA's comments with you and your team during several meetings. Our exchanges served to greatly clarify for Boeing EPA's questions and concerns with the draft. A summary of specific responses to individual comments is attached.

If you have no further questions or comments and following your approval, we will continue with IM optimization through augmentation of the Enhanced Reductive Dechlorination process and associated monitoring at both IM sheetpile locations. In the meantime, we are continuing with the SVE shutdown/rebound test portion of the Work Plan at both sheetpile locations as previously approved.

We look forward to your approval of this document so this IM work may proceed. Please contact me or Will Ernst with any questions or comments you may have on this request.

Sincerely,

Digitally signed by
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Enclosure and attachment

cc: Hideo Fujita – Washington Dept of Ecology (w/ CD copy)

**Boeing Plant 2**
**Seattle/Tukwila, Washington**

# Remedial Optimization for the 2-10 Interim Measures

# Technical Memorandum

**Prepared for**

The Boeing Company
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**Prepared by**

CALIBRE
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**Agency Review Draft**

July 29, 2014

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# List of Abbreviations and Acronyms

| Acronym/ Abbreviation | Definition |
|---|---|
| AOC | Area of Concern |
| Boeing | The Boeing Company |
| bgs | Below ground surface |
| CSM | Conceptual Site Model |
| CVOC | Chlorinated volatile organic compound |
| DCE | Dichloroethylene, aka dichloroethene |
| DHE | Dehalococcoides ethenogenes |
| DQO | Data Quality Objective |
| ERD | Enhanced reductive dechlorination |
| FMCL | Final Media Cleanup Level |
| ft/day | Feet per day |
| IM | Interim Measure |
| µg/L | Micrograms per liter |
| µg/m$^3$ | Micrograms per cubic meter |
| MTCA | Model Toxics Control Act |
| RCRA | Resource Conservation and Recovery Act |
| SVE | Soil vapor extraction |
| TCE | Trichloroethene |
| UIC | Underground Injection Control |
| USEPA | U.S. Environmental Protection Agency |
| VC | Vinyl chloride |
| VOC | Volatile organic compound |

# 1.0 Introduction and Site Background

Interim Measures (IMs) have been implemented at the north and south sheetpile areas in the Building 2-10 Area (Areas of Concern [AOCs] 2-10.3A and 2-10.4A). The site is located at Boeing Plant 2 in Seattle/Tukwila, Washington. The IMs have been performed in accordance with the approved Work Plan (CALIBRE and Floyd|Snider 2010). The IMs described in this report have been implemented to reduce/remove volatile organic compounds (VOCs) in groundwater, soil, and soil vapor from both AOCs.

The work has been implemented under the Resource Conservation and Recovery Act (RCRA) Administrative Order on Consent, between The Boeing Company (Boeing) and the U.S. Environmental Protection Agency (USEPA) Region 10 ([RCRA Docket No. 1092-01-22-3008(h)]; USEPA 1994). This technical memorandum has been prepared to summarize the IM activities completed to date and describe future activities (proposed) to optimize the corrective measures/remedial actions implemented. The two corrective measures/remedial actions implemented as the IMs include soil vapor extraction (SVE; for VOCs in vadose zone soils) and enhanced reductive dechlorination (ERD; for VOCs in groundwater). These same two technologies (SVE and ERD) have been implemented in the IMs at both the north and south sheetpile areas.

The information presented is organized as follows: Section 1.0 Introduction and Site Background; Section 2.0 SVE Operations/Performance Summary; Section 3.0 SVE System Optimization; Section 4.0 ERD Summary/Optimization Procedures for Groundwater; Section 5.0 Recommendations and Schedule; and Section 6.0 References. Appendix A includes a summary of current IM performance monitoring data (SVE monitoring/VOC mass removal and groundwater monitoring data). Appendix B includes a short summary of other historical data relevant to the IM planning and implementation (the initial Conceptual Site Model [CSM], bacterial counts for *Dehalococcoides ethenogenes* [DHE] and indoor air sampling data, all from prior reports).

## 1.1 SITE LOCATION

Plant 2 is located on approximately 107 acres between the Duwamish Waterway and East Marginal Way South, in Seattle/Tukwila, Washington (refer to Figure 1.1). Plant 2 began operating in 1936 and the facility contains numerous manufacturing and process buildings related to aircraft fabrication. Portions of Plant 2 (including operations in the 2-10 Building) continue to support aerospace manufacturing. Figure 1.2 presents the location of the 2-10 Area, the sheetpile areas, and other features in the immediate area. A general description of the site hydrogeology and summary of previous investigations is presented in the RCRA Facility Investigation Groundwater Investigation Interim Report (Weston 1996).

## 1.2 SITE HISTORY/NATURE OF CONTAMINATION

The initial site investigations (started in 1992) identified a trichloroethene (TCE) release to soil and groundwater at each of two degreaser areas in the 2-10 Building (refer to Figure 1.2). Boeing implemented interim corrective measures at these two areas in 1993 (Weston 1993) with a containment technology using sheetpile walls constructed around each area. The work was initiated in late 1993 and completed in April 1994 (Weston 1994). The 2-10 Building was an active manufacturing facility when the sheetpiles were installed. Due to the ongoing manufacturing operations within the building, the sheetpiles were aligned where access was feasible. The bulk of the VOC plumes were contained with only small plume areas excluded due to access limitations during sheetpile installation. The south sheetpile area excluded a small portion of the plume to the east (upgradient of the structure near well PL2-257A). The north sheetpile area excluded a small portion of the western edge of the VOC plume (near wells PL2-258A/B/C). The north sheetpile was installed to a depth of 30 feet below ground surface (bgs) and the south sheetpile was installed to a depth of 25 feet bgs. Both of the sheetpiles are hanging sheetpiles, meaning that they are not keyed into a low permeability unit at their base (none was available). Instead they use hydraulic gradients to limit loss of contaminants from their base. That is, the net hydraulic gradient is neutral or upward, so little contamination is lost from the structure. A detailed effectiveness evaluation of the two sheetpile structures was performed in 2001, demonstrating continued containment effectiveness (Weston 2001).

The IM design data (chlorinated volatile organic compound [CVOC] levels in groundwater and soil vapor collected in 2010) showed that elevated levels of TCE remained in the sheetpile areas near the former degreaser locations. Monitoring data collected downgradient of the source areas (but still within the contained areas) showed that as the VOC plume moves westward the biodegradation daughter products of cis-1,2 dichloroethene (cis-1,2-DCE) and vinyl chloride (VC) are generated.

### 1.3 SUMMARY OF CONCEPTUAL SITE MODEL

A CSM was developed as part of the initial project planning (CALIBRE and Floyd|Snider 2009). The initial CSM is provided in Appendix B and includes details on:

1. History and Background/Site Setting and Boundaries
2. Geology and Hydrogeology
3. Source(s) of Chemical Release/Chemicals of Concern
4. Potential For dense non-aqueous phase liquid (DNAPL) Occurrence
5. Fate and Transport Pathways/Exposure Pathways
6. Corrective Measures Implemented to Date
7. Performance Metrics

Some of the important hydrogeologic parameters in the CSM include the aquifer properties (hydraulic, conductivity, gradient, and corresponding groundwater transport velocity). The hydraulic conductivity (K) is estimated at 270 feet per day (ft/day) based on an aquifer pumping test[1] in the area (Weston 1992). Groundwater is tidally influenced and flows in a direction generally perpendicular to the adjacent Duwamish Waterway. The gradient (i) has been measured at 0.001 feet per foot (tidally averaged), with a calculated groundwater pore velocity of 1.1 ft/day (based on K, i, and porosity of 25 percent). Subsequent to the initial development of the CSM, the IM corrective measures were implemented (SVE and ERD, as described above) and performance monitoring data were collected. A summary of IM data to refine the CSM and evaluate performance metrics is presented in the following sections for the north and south sheetpile areas.

[1] The 1992 aquifer pumping test was conducted using well PL2-224, located about 300 feet east of the 2-10 Building and included monitoring points from depths of 15 to 45 feet bgs (Weston 1992). Other areas of the Plant 2 property have identified generally similar hydraulic properties with small variations in the estimated conditions/calculated groundwater pore velocity.

### 1.3.1 Recent Conditions: North Sheetpile Area

The layout of monitoring wells and ERD injection wells for the north sheetpile area are shown in Figure 1.3. The north sheetpile area includes a small VOC plume area located outside of the sheetpile on the downgradient (west) side (near wells PL2-258A PL2-258B). Recent performance monitoring data (VOCs in groundwater) are presented as a cross-section on Figure 1.4. The time-series of recent VOC concentration data for monitoring wells PL2-212A, PL2-258A, and PL2-258B are shown in Figures 1.5, 1.6, and 1.7.

Key details of the recent performance monitoring data in the north sheetpile area include:

- The TCE concentration in well PL2-212A (monitoring the source area) is down to 0.3 micrograms per liter (µg/L), which is a 99.999 percent reduction compared to 62,000 µg/L at the start of ERD treatment. In addition, the TCE degradation daughter products (cis-1,2-DCE and VC) are all showing rapid and significant reductions (99.8 percent reduction).
- Wells PL2-218A and PL2-218B appear to be responding slower (these two wells are within the sheetpile and 150 feet downgradient from the source area). Well PL2-218A maintained relatively stable CVOC concentrations for the first 2 years of ERD treatment but has recently shown significant reductions (99 percent reductions as of April 2014). Well PL2-218B has also declined (overall CVOC reductions are about 92 percent as of April 2014), but may be at a condition where the degradation process has slowed at cis-1,2-DCE. This specific area and depth (PL2-218B) had bacterial counts in prior sampling events and indicated lower DHE counts for samples collected in 2010 (CALIBRE and Floyd|Snider 2010) and 2012 (CALIBRE 2013). Bio-augmentation in this area is recommended and discussed further in Section 4.0.
- The SVE system in the north sheetpile area has operated for approximately 16 months. Performance monitoring data from the SVE system demonstrate significant declines in VOC vapors (99.9 percent reductions based on measurement of soil vapor concentration and inlet concentrations to the SVE system). Based on the performance data, the north area SVE system is recommended for shutdown and rebound testing; this recommendation is discussed further in Sections 2.0 and 3.0. (Note: approval to begin SVE system shutdown and rebound testing was granted by USEPA on June 19, 2014.)
- Compliance wells near the shoreline (PL2-258A and PL2-258B) outside of the north sheetpile are in compliance with the groundwater Final Media Cleanup Levels (FMCLs) in the most recent (April 2014) event.[2]

### 1.3.2 Recent Conditions: South Sheetpile Area

The layout of monitoring wells and ERD injection wells for the south sheetpile area are shown in Figure 1.8. The south sheetpile area includes a small VOC plume area located outside of the sheetpile on the upgradient (east) side (near well PL2-257A). This area is a stagnation point in the groundwater flow path toward, and subsequently around, the south sheetpile. The predicted flow paths (and stagnation point near well PL2-257A) are shown in Figure 1.9. The VOC characterization data for the south sheetpile area have included multiple historical probe sampling locations installed to evaluate the migration potential for this area outside of the sheetpile (near well PL2-257A).

[2] Groundwater FMCLs for these chemicals are 130 µg/L for cis-1,2-DCE, 1.4 µg/L for TCE; and 2.4 µg/L for VC.

Recent performance data and historical monitoring data (VOCs in groundwater) are presented as a plan view in Figure 1.10 and as a cross-section in Figure 1.11. The cross-section data include multiple locations (both probes and monitoring wells) beneath the base of the sheetpile that demonstrate that the plume has not migrated beneath the sheetpile.

Key details of the recent performance monitoring data in the south sheetpile area include:

- Well PL2-209A (near the former degreaser inside the south sheetpile) has declined steadily since the start of ERD treatment. The most recent VC concentrations (April 2014) have declined to 4.8 µg/L (about 2 times the FMCL), while TCE is at 0.3 µg/L and cis-1,2-DCE is at 3.1 µg/L, less than their respective FMCLs. The deeper well in this area, PL2-209B, is at non-detect (<0.2 µg/L) for all CVOCs.
- Well PL2-253A (downgradient inside the south sheetpile) is less than FMCLs and approaching non-detect levels (VC was the only detection at 0.2 µg/L). Similar results are seen at PL2-256A (upgradient side inside the south sheetpile), which is approaching non-detect levels (VC was the only CVOC detection at 0.5 µg/L).
- Shoreline wells PL2-214A and PL2-214B (downgradient outside the south sheetpile) are in compliance with the FMLCs at non-detect levels.
- Well PL2-257A (outside south sheetpile, upgradient side at/near stagnation point) is responding slower. CVOC concentrations have declined with ERD treatment, but this area may be at a condition where the degradation process has slowed at cis-1,2-DCE (although VC is detected). This specific area (PL2-257A) indicated lower DHE counts in samples collected in 2012 (CALIBRE 2013). Bio-augmentation in this area is recommended and discussed further in Section 4.0.
- The SVE system in the south sheetpile area has operated for approximately 16 months. Performance monitoring data from the SVE system demonstrate significant declines in VOC vapors (99+ percent reductions based on measurements of soil vapor concentration and inlet concentrations to the SVE system). Based on the performance data, the south area SVE system is recommended for shutdown and rebound testing; this recommendation is discussed further in Sections 2.0 and 3.0. (Note: approval to begin SVE system shutdown and rebound testing was granted by USEPA on June 19, 2014.)

# 2.0 SVE Operations/Performance Summary

The present IMs include a total of four remediation systems; two SVE systems and two ERD injection networks. The remediation systems construction and operations are summarized in the Interim Status Report Construction Summary (CALIBRE 2013).

## 2.1 NORTH SVE SYSTEM SUMMARY

The north area SVE system consists of five vapor extractions wells and the SVE equipment system; locations are shown in Figure 2.1. The north area SVE system started operation on January 14, 2013 and has removed an estimated 40 pounds of TCE after 16 months of operation. Appendix A presents the operations monitoring data and estimated mass removed from the north area SVE system. The initial mass removal rate for the north area SVE system was approximately 0.15 pounds of TCE per day (not including a brief initial period of higher removal rates, which lasted approximately 3 to 4 days). After 1 year of operation, the mass removal rate had fallen to 0.02 pounds per day, and operational changes were made, which resulted in moderate increases in the removal rate (up to 0.03 pounds per day). Operational monitoring demonstrates that TCE vapor concentrations have decreased significantly from startup conditions. The VOC mass removal data over the operating period for the north area SVE system are shown in Figure 2.2 and additional data on current soil vapor levels are presented in a subsequent section (Section 2.3). Based on these performance monitoring data, the north area SVE system has met the remedial objectives and is ready for shutdown tests. The planned testing associated with shutdown procedures will include rebound testing to verify conditions (discussed in Section 3.0).

## 2.2 SOUTH SVE SYSTEM SUMMARY

The south area SVE system consists of two vapor extractions wells and the SVE equipment system; locations are shown in Figure 2.1. The south area SVE system started operation on January 8, 2013 and has removed an estimated 5.7 pounds of TCE after 16 months of operation. Appendix A presents the operations monitoring data and estimated mass removal from the south area SVE system. The initial mass removal rate for the south area SVE system was approximately 0.05 pounds of TCE per day (not including a brief initial period of higher removal rates, which lasted approximately 1 day). After 1 year of operation the mass removal rates had fallen to 0.003 pounds per day. Similar to the north area SVE system, operational monitoring indicates vapor concentrations have decreased significantly from startup conditions. The VOC mass removal data over the operating period for the south area SVE system are shown in Figure 2.3 and additional data on current soil vapor levels are presented in the following section (Section 2.3). Based on these performance monitoring data, the south area SVE system has met the remedial objectives and is ready for shutdown tests. The planned testing associated with shutdown procedures will include rebound testing to verify conditions.

## 2.3 SOIL VAPOR CONDITIONS

Prior to the installation and operation of the IMs, soil vapor conditions were investigated to provide data on the baseline conditions. Tables 2.1 and 2.2 provide soil vapor pre-IM baseline data from monitoring points PL2-SSL-1/PL2-SSL-4 in the north sheetpile area and Tables 2.3 and 2.4 from monitoring points PL2-SSL-5/PL2-SSL-7 in the south sheetpile area. The baseline data demonstrate vapor concentrations were highest at the points near the former degreaser pits. The sampling locations are shown in Figure 2.4. Two of these vapor monitoring points (the two locations with the higher vapor concentrations, PL2-SSL-1 and PL2-SSL-7) were re-sampled on December 18, 2013 to measure current soil vapor concentrations (after approximately 11 months of SVE operation). The SVE systems were shut down approximately 1 hour prior to this sampling event (December 2013). The post-first year sample results are also shown in Table 2.1 for the north sheetpile area and Table 2.4 for the south sheetpile area.

Analytical results indicated a 99.97 percent reduction in CVOC concentrations at location PL2-SSL-1 (north SVE area, adjacent to former degreaser pit) and a 99.3 percent reduction in CVOC concentrations in location PL2-SSL-7 (south SVE area, adjacent to former degreaser pit location). Refer to Tables 2.1 and 2.4 for details.

In addition to the baseline soil vapor sampling, indoor air sampling was performed in late 2009 at 19 locations throughout the 2-10 Building. The analytical results for all indoor air samples indicated TCE concentration at levels less than the Model Toxics Control Act (MTCA) Method C standard of 6.5 micrograms per cubic meter ($\mu g/m^3$); this criterion is based on the most recent toxicity factors published by the USEPA in the Integrated Risk Information System (IRIS) and adopted by Washington State Department of Ecology in 2012. Detailed information about the 2009 indoor air sampling is contained in the document *Uplands Corrective Measures Volume IX: 2-10 Area Data Gap Investigation; Attachment E Report on Vapor Intrusion Sampling Building 2-10*, dated May 2010 (Golder 2010). A short synopsis of the 2009 indoor air sampling data is presented in Appendix B (a data summary table and a plot of the sampling locations [indoor air] throughout the 2-10 Building).

These baseline monitoring data demonstrate that the indoor air exposure pathway does not exceed applicable risk-based standards based on the site-specific monitoring data and building conditions (i.e., relatively high VOC levels were detected in soil vapor samples whereas all indoor air samples were less than the MTCA Method C standard before the IMs were initiated). Based on these conditions and initial discussions with USEPA on February 13, 2014, it was agreed that the current soil vapor concentrations (with a 99+ percent reduction from the baseline levels as a result of the IM work) would not pose a risk to indoor air quality and the indoor air pathway is not a concern in relation to shutdown of the present SVE operations.

**Table 2.1**
**PL2-SSL-1 - Soil Vapor (North Sheetpile Near Former Degreaser)**

| Sample Location | Sample Depth (ft) | Method | Parameter | Units | Result | Flags | Reporting Limit |
|---|---|---|---|---|---|---|---|
| *Sample Date: 2/12/10* | | | | | | | |
| PL2-SSL-1 | 8 | TO-15 | Tetrachloroethene | ppbv | <760 | U | 760 |
| | | | Trichloroethene | ppbv | 240,000 | | 760 |
| | | | cis-1,2-Dichloroethene | ppbv | 14,000 | | 760 |
| | | | trans-1,2-Dichloroethene | ppbv | 970 | | 760 |
| | | | Vinyl Chloride | ppbv | <760 | U | 760 |
| | | | Tetrachloroethene | ppbv | <760 | U | 760 |
| | | | Trichloroethene | ppbv | 260,000 | | 760 |
| | | | cis-1,2-Dichloroethene | ppbv | 14,000 | | 760 |
| | | | trans-1,2-Dichloroethene | ppbv | 1,000 | | 760 |
| | | | Vinyl Chloride | ppbv | <760 | U | 760 |
| *Sample Date: 12/18/2013* | | | | | | | |
| PL2-SSL-1 | 8 | TO-15 | Tetrachloroethene | ppbv | <0.5 | U | 0.5 |
| | | | Trichloroethene | ppbv | 84 | | 0.5 |
| | | | cis-1,2-Dichloroethene | ppbv | 2.9 | | 0.5 |
| | | | trans-1,2-Dichloroethene | ppbv | <0.5 | U | 0.5 |
| | | | Vinyl Chloride | ppbv | <0.5 | U | 0.5 |
| **Result: 99.97% Reduction from 2010 Levels** | | | | | | | |

Abbreviations:
ft Feet
ppbv Parts per billion by volume

Qualifier:
U The analyte was analyzed for, but was not detected at levels greater than the reported sample quantitation limit.

**Table 2.2**
**PL2-SSL-4 - Soil Vapor (North Sheetpile Downgradient from Former Degreaser)**

| Sample Location | Sample Depth (ft) | Method | Parameter | Units | Result | Flags | Reporting Limit |
|---|---|---|---|---|---|---|---|
| *Sample Date: 2/11/10* | | | | | | | |
| PL2-SSL-4 | 8 | TO-15 | Tetrachloroethene | ppbv | <19 | U | 19 |
| | | | Trichloroethene | ppbv | 7,700 | | 19 |
| | | | cis-1,2-Dichloroethene | ppbv | 280 | | 19 |
| | | | trans-1,2-Dichloroethene | ppbv | <19 | U | 19 |
| | | | Vinyl Chloride | ppbv | <19 | U | 19 |
| | | | Chloroform | ppbv | 27 | | 19 |

Note:

Not sampled in 2013.

Abbreviations:

ft Feet

ppbv Parts per billion by volume

Qualifier:

U The analyte was analyzed for, but was not detected at levels greater than the reported sample quantitation limit.

## Table 2.3
## PL2-SSL-5 - Soil Vapor (South Sheetpile Downgradient from Former Degreaser)

| Sample Location | Sample Depth (ft) | Method | Parameter | Units | Result | Flags | Reporting Limit |
|---|---|---|---|---|---|---|---|
| *Sample Date: 2/12/10* | | | | | | | |
| PL2-SSL-5 | 8 | TO-15 | Tetrachloroethene | ppbv | <1.9 | U | 1.9 |
| | | | Trichloroethene | ppbv | 360 | | 1.9 |
| | | | cis-1,2-Dichloroethene | ppbv | 13 | | 1.9 |
| | | | trans-1,2-Dichloroethene | ppbv | <1.9 | U | 1.9 |
| | | | Vinyl Chloride | ppbv | <1.9 | U | 1.9 |
| | | | Ethanol | ppbv | 34 | | 7.8 |
| | | | Acetone | ppbv | 16 | | 7.8 |
| | | | 2-Propanol | ppbv | 18 | | 7.8 |
| | | | Hexane | ppbv | 2.7 | | 1.9 |
| | | | 2-Butanone | ppbv | 12 | | 1.9 |
| | | | Cyclohexane | ppbv | 16 | | 1.9 |
| | | | Heptane | ppbv | 160 | | 1.9 |
| | | | Toluene | ppbv | 130 | | 1.9 |
| | | | m,p- Xylene | ppbv | 3.4 | | 1.9 |

Note:
Not sampled in 2013.

Abbreviations:
ft Feet
ppbv Parts per billion by volume

Qualifier:
U The analyte was analyzed for, but was not detected at levels greater than the reported sample quantitation limit.

**Table 2.4**
**PL2-SSL-7 - Soil Vapor (South Sheetpile Near Former Degreaser)**

| Sample Location | Sample Depth (ft) | Method | Parameter | Units | Result | Flags | Reporting Limit |
|---|---|---|---|---|---|---|---|
| *Sample Date: 2/11/10* | | | | | | | |
| PL2-SSL-7 | 8 | TO-15 | Tetrachloroethene | ppbv | <49 | U | 49 |
| | | | Trichloroethene | ppbv | 17,000 | | 49 |
| | | | cis-1,2-Dichloroethene | ppbv | <49 | U | 49 |
| | | | trans-1,2-Dichloroethene | ppbv | <49 | U | 49 |
| | | | Vinyl Chloride | ppbv | <49 | U | 49 |
| *Sample Date: 12/18/2013* | | | | | | | |
| PL2-SSL-7 | 8 | TO-15 | Tetrachloroethene | ppbv | <0.5 | U | 0.5 |
| | | | Trichloroethene | ppbv | 120 | | 0.5 |
| | | | cis-1,2-Dichloroethene | ppbv | <0.5 | U | 0.5 |
| | | | trans-1,2-Dichloroethene | ppbv | <0.5 | U | 0.5 |
| | | | Vinyl Chloride | ppbv | <0.5 | U | 0.5 |
| | | | | | | | **Result: 99.3% Reduction from 2010 Levels** |

Abbreviations:
ft Feet
ppbv Parts per billion by volume

Qualifier:
U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

# 3.0 SVE System Optimization

As shown in data presented in Section 2.0, the two SVE systems have achieved the stated remedial action goals. The following sections describe procedures to be used for establishing conditions in which the SVE systems may be shut down and further remediation efforts, for this IM, will be completed solely by ERD treatment of groundwater and periodic monitoring.

## 3.1 DATA REQUIREMENTS FOR SVE OPERATION/SHUTDOWN TESTING

A Data Quality Objectives (DQO) process was initially used to identify specific data requirements for optimization of SVE operation. The DQO process is structured around the following basic steps:

1. Define the problem statement/objectives.
2. Define the boundaries of the study.
3. Identify anticipated project decisions that must be made in order to select the best response for the defined problem.
4. Identify the data necessary to make those decisions (including a review of existing data and summary of other data necessary for a decision).
5. Identify data gaps within the existing data that must be addressed to make the decisions from Step 3.
6. Identify the preliminary decision criteria/thresholds that can be used to formulate decision rules linking actions to the outcome of efforts to fill data gaps identified in Step 5.

Table 3.1 presents a summary of the DQO process specific to the SVE operations and shutdown criteria.

**Table 3.1**
**Data Quality Objectives Process and Data Summary**

| DQO Process Step | Application to SVE Rebound Test for 2-10s IM | Existing Data | Additional Data Required to Support Optimization of Interim Measures |
|---|---|---|---|
| The problem to be resolved at the site | Current/ongoing IM activities at the site have removed contaminant concentrations from both groundwater and vadose zones. The SVE systems have removed the bulk of vadose zone/vapors present. Protocols for evaluating and demonstrating when the SVE systems may be shut down need to be developed. | Soil vapor data, groundwater monitoring data.<br>Mass removal estimates from SVE monitoring, calculated half-lives and mass removal rates from ERD degradation. | Soil vapor concentration data after the SVE systems are shut down and in situ concentrations allowed to rebound. |
| The boundaries of the study | IM areas within the 2-10 Building VOC Plumes.<br>Horizontal and vertical boundaries of the plumes.<br>Consideration of the key processes controlling the two potential exposure pathways (vapor intrusion and leaching to groundwater with exposure via discharge to surface water). | Historical/on-going groundwater data depicting the groundwater plume (the bulk of which is contained within the sheetpile areas).<br>Prior to IM initiation, indoor air monitoring was completed and all data indicated results less than the MTCA ARAR of 6.5 µg/m$^3$ (Method C for indoor air TCE in an industrial setting); the highest TCE detection in indoor air was 1.9 µg/m$^3$.<br>Soil vapor data from December 2013 after SVE systems running for 11 months (indicating 99+ percent reductions in soil vapor). | |

**Table 3.1**
**Data Quality Objectives Process and Data Summary**

| DQO Process Step | Application to SVE Rebound Test for 2-10s IM | Existing Data | Additional Data Required to Support Optimization of Interim Measures |
|---|---|---|---|
| The decisions needed to resolve the problem | 1) If SVE systems are shut down, will soil vapor concentrations rebound to levels that would cause indoor air levels to increase higher than risk-based criteria (MTCA Method C)? | Prior to initiation of SVE systems operation, indoor air was monitored and all detections were less than applicable ARARs. The SVE operations have removed significant VOC mass from vadose zone, monitoring data have demonstrated a 99+ percent reduction in soil vapor levels. All existing data indicate that indoor air levels will continue to be less than applicable criteria. | No additional monitoring data necessary (for indoor air pathway). Data collected prior to the IM startup indicated indoor air concentrations less than ARARs (for industrial exposure) and SVE systems operation have reduced soil vapor concentrations by more than 99 percent. |
| | 2) If SVE systems are shut down, will the residual soil vapor concentrations rebound to levels that could cause increased leaching to groundwater at concentrations that cannot be effectively/readily treated with the ERD remedy that has already been implemented? | Current groundwater monitoring data indicate VOCs still present throughout the bounded areas at levels greater than applicable criteria. | Soil vapor data after an SVE system shutdown for rebound testing purposes. |
| The inputs to the decision | Conceptual site model and exposure pathways, current groundwater data, soil vapor data, and SVE monitoring data. | Operational data collected to date:<br>SVE vapor removal concentrations and mass removal rate.<br>Vapor monitoring data from selected vadose zone wells.<br>Groundwater monitoring data under ERD conditions. | In situ vapor concentrations after SVE systems have been shut down.<br>Groundwater sampling.<br>Comparison of current SVE mass removal rates with ERD removal rates. |
| The decision rules | If…/then… format with quantitative limits:<br>To be developed. | | |

## 3.2 SVE REBOUND TEST PROCEDURES

This section presents the rebound test procedures for the SVE systems (applicable to both the north and south SVE systems). The basic condition to initiate a rebound test is that the SVE system has reached an asymptote where the influent vapor concentrations have decreased to levels low enough that they no longer pose an exposure risk and (typically) the mass removal rate has decreased to levels that are no longer cost-effective to remove through continued SVE operation. All SVE systems eventually encounter such conditions. An example of where the SVE system is no longer cost-effective might include the slow recovery of vapors transferred from the water table to the vadose zone (in this case groundwater treatment would likely be a more effective approach) rather than further recovery of low-level vapors from soil.

The existing SVE and groundwater monitoring data demonstrate that:

1. The vapor concentrations have declined significantly (greater than 99+ percent reduction).
2. Exposure via an indoor air pathway is no longer a significant concern.
3. The mass removal (in the north and south area SVE systems) appears to have reached an asymptote where the influent vapor concentrations and corresponding mass removal are very low.
4. Groundwater concentrations of VOCs have declined (with the ERD treatment) and the TCE concentrations in groundwater (the primary constituent of concern [COC] detected in soil vapor measurements) have been significantly reduced (or eliminated) from most wells.

There are a variety of guidance documents (and general rules of thumb) regarding SVE rebound testing. The California Department of Toxic Substance Control (CAL DTSC 2006) suggests a 2-week rest period at fuel release sites prior to the SVE system re-start. The U.S. Army Corps of Engineers suggests a 30-day initial rest period followed by a 60-day follow-up period if testing from the 30-day period does not show levels greater than the shutdown criteria (USACE 2002).

Each of the IM SVE systems will initially be shut down for a period of approximately 30 days. After the rest period, key vapor points will be monitored with a field photoionization detector (PID) to determine if vapor concentrations have rebounded. Some level of rebounding is expected with the shutdown and re-start of the SVE systems. The operational question is whether sufficient vapor accumulates to make further mass recovery via SVE effective. If concentrations appear to have rebounded, the system will be started and operated for approximately 1 hour. Following the 1-hour operating period, field measurements will be repeated, and the same operations and measurements will be repeated after a 3-hour operating period. After review of the rebound test data from the 30-day rest period, the same procedures will be implemented after a 60-day rest period. The vapor monitoring points to be tested in the north SVE area include PL2-SSL-1, PL2-SSL-4, SVE-N-1, SVE-N-4, SVE-N-2, and SVE-N-3. The vapor monitoring points to be tested in the south SVE area include PL2-SSL-7, PL2-SSL-5, SVE-S-7, and SVE-S-5.

The SVE rebound test data will be evaluated to answer the following questions:

1. Is the risk of indoor air exposure greater than applicable MTCA standards likely? (Present data indicate this is highly unlikely.)
2. Is the increased mass removal rate sustained for any significant time period after a rest/rebound period and is the mass removed sufficient to justify prolonged SVE system operation?
3. Are there data to indicate that continued SVE system operation was having a measurable improvement on the groundwater system, over and beyond what is being accomplished with the groundwater ERD system?

The SVE rebound test data, combined with the evaluations noted above, will be used to make recommendations regarding SVE operations. Alternatives are either to shut the systems down, or to continue system operation, perhaps on a modified schedule or configuration. Separate recommendations will be prepared for the north and south SVE systems.

# 4.0 ERD Summary/Optimization Procedures for Groundwater

The following section summarizes current groundwater conditions in relation to the ongoing ERD treatment in and around the sheetpile areas. The summary presented below reflects conditions as of April 2014.

## 4.1 GROUNDWATER PERFORMANCE MONITORING DATA – NORTH SHEETPILE AREA

Current groundwater conditions within the north sheetpile area indicate that dechlorination is underway and progressing fully, from TCE through all daughter products to ethene. Wells of note include the source area monitoring well PL2-212A (adjacent to the north area degreaser pit). Total CVOCs in this well (PL2-212A) have decreased from 92,310 µg/L in March 2010 to 154 µg/L in April 2014 (including TCE levels under 1 µg/L). High levels of ethene (220 µg/L) indicate full dechlorination is occurring. Data from shoreline compliance well PL2-258A, located near the Duwamish Waterway, indicate a continued downward trend of CVOCs since the start of the IM (CVOCs decreasing from 707 µg/L in August 2012 down to 0.9 µg/L in April 2014). Wells PL2-218A and PL2-218B (within the sheetpile) appear to be responding slower to the bio-stimulation. Well PL2-218A maintained relatively stable VOC concentrations for the first 2 years of ERD treatment, but has recently shown significant reductions (99 percent reductions as of April 2014). Well PL2-218B may be at a condition where the degradation process has slowed at cis-1,2-DCE; however, overall VOC reductions are significant, being about 92 percent as of April 2014, and further bio-augmentation may accelerate the dechlorination process. This specific area and depth (PL2-218B) had indicated lower DHE counts in the two prior samples (collected in 2010 and 2012). Bio-augmentation in this area and further IM monitoring are recommended to stimulate continued and accelerated dechlorination. This proposed action is discussed further in Section 4.3. The groundwater performance monitoring data are provided in Appendix A.

## 4.2 GROUNDWATER PERFORMANCE MONITORING DATA – SOUTH SHEETPILE AREA

Groundwater conditions for the south sheetpile area indicate that dechlorination is underway and progressing fully, from TCE through all daughter products to ethene with the exception of one well. This well, PL2-257A, located upgradient and outside the sheetpile, has shown slower dechlorination rates since the start of ERD treatment (TCE is largely removed down to 1 µg/L but cis-1,2-DCE and VC are degrading at a slower rate). This well is separated from other wells by the sheetpile, and it is likely that the species populations of dechlorinating bacteria required for full dechlorination to ethene are more limited. Bio-augmentation is recommended to stimulate continued and accelerated dechlorination. Data from other wells sampled as part of the ongoing monitoring program indicate full dechlorination and downward trends in CVOC concentrations. Of note is well PL2-253A; analytical results indicate current VC concentrations of 0.2 µg/L (much less than the VC FMCL of 2.4 µg/L) down from 106 µg/L in March 2010. Shoreline wells PL2-214A and PL2-214B (outside the south sheetpile) are at non-detect levels. The groundwater performance monitoring data are provided in Appendix A.

## 4.3 RECOMMENDED OPTIMIZATION FOR ERD TREATMENT

Reductive dechlorination is a biological process and the general degradation/dechlorination steps are shown in Figure 4.1. As a biotic process, specific bacterial microorganisms are necessary to facilitate the dechlorination steps from TCE through cis-1,2-DCE and VC to ethene. Abiotic dechlorination processes[3] are also known to exist, but abiotic reaction rates are generally much slower (Dong et al. 2009) and, therefore, are only important where biotic reaction rates are slow.

The specific microorganisms that facilitate dechlorination have been the subject of extensive research for several decades (Bouwer and McCarty 1983, Freedman and Gossett 1989, Davis and Carpenter 1990, Gibson and Sewell 1992, Nyer et al. 2003, and Major et al. 2003). Based on existing information and practical applications, at least one microorganism (DHE) has been identified that is effective at completing reductive dechlorination to ethene under suitable conditions (He et al. 2003). In addition, other bacteria that thrive in similar reduced environments have also been shown to complete dechlorination of solvents to ethene (He et al. 2002). Some literature regarding ERD applications suggest that bio-augmentation may not be necessary in some cases (Nyer et al. 2003, Fowler et al. 2013). However, the majority of successful ERD applications implement bio-augmentation if/when cis-1,2-DCE stall is observed; it is a simple, cost-effective action that has been successfully implemented at many sites. Bio-augmentation was identified in the initial IM work plan (CALIBRE and Floyd|Snider 2010) and further discussed as a prospective remedial optimization measure in the IM Startup/Construction Summary Report (CALIBRE 2013).

As introduced above, based on past and current monitoring data from well PL2-257A in the south sheetpile area, and wells PL2-218A and PL2-218B in the north sheetpile area, the dechlorination process is not progressing at the same rate as at other nearby locations. Prior bacterial count sampling in these two areas (in 2010 and 2012) indicated a lower bacterial count for DHE in these specific areas (before ERD was started in 2010 and after a period of bio-stimulation in 2012; refer to data in Appendix B). Water quality testing in these areas has demonstrated that the bio-stimulation (substrate injection) has created anaerobic, reducing conditions suitable for ERD. In order to increase the dechlorination rate, it is proposed that bio-augmentation be initiated in wells PL2-218A/PL2-218B (north sheetpile area; refer to Figure 4.2) and PL2-257A and IW-S-12 (south sheetpile area; refer to Figure 4.3). The bio-augmentation will use a laboratory-grade culture of a species of *Dehalococcoides* (the bacteria responsible for dechlorination of DCE and VC to ethene). Each well will be inoculated according to manufacturer specifications.

Prior to injection/bio-augmentation, an Underground Injection Control (UIC) registration will be completed for all wells and all injection materials (consistent with the project Work Plan). Copies of the UIC registration will be provided to USEPA after approval of this Technical Memorandum and prior to starting the bio-augmentation work.

Performance monitoring to verify effectiveness of bio-augmentation will include sampling of the injection wells and downgradient monitoring wells. The injection wells will be sampled to demonstrate that daughter products are generated and dechlorination is continuing. In the north sheetpile area, monitoring well PL2-258B will serve as a performance monitoring location located downgradient of PL2-218B (this well is currently sampled as part of the IM performance monitoring plan, sampled quarterly). The travel

[3] The abiotic dechlorination of TCE (described as β-elimination) involves reactions with Ferrous sulfide (FeS) minerals. Abiotic dechlorination steps result in direct conversion of TCE to acetylene (without production of cis-1,2-DCE and VC). The relative importance of abiotic and biotic dechlorination rates have been compared in various studies. Based on microcosm studies, the rate of abiotic transformation was important (i.e., similar in magnitude to those for biotic dechlorination rates) in only a few cases where the biotic dechlorination rates were low.

distance to this downgradient location is approximately 65 feet (from PL2-218B to PL2-258B) and the pore velocity is estimated at 1.1 ft/day[4] yielding an estimated travel time of approximately 60 days.

In the south sheetpile area, monitoring well PL2-257A will serve as a performance monitoring location; this well is located at/near the stagnation point on the upgradient side of the sheetpile barrier (refer to Figure 1.9). In addition, the downgradient monitoring points along the projected flow path will include wells PL2-214A and PL2-216A. Well PL2-214A is part of the Shoreline Monitoring Program (refer to data in Figure 1.10). The travel distance to these downgradient locations is approximately 220 feet and the estimated travel time is approximately 200 days. These two added wells (PL2-214A and PL2-216A) will be sampled twice a year as part of the IM performance monitoring program for the next 2 years.

## 4.4 RECOMMENDED CHANGES TO GROUNDWATER MONITORING

The initial monitoring plan for the IM was based on proving the efficacy of the ERD treatment process and collecting sufficient data for remedial optimization. Current monitoring data from multiple wells has provided data sufficient to demonstrate that the ERD treatment process is effective (e.g., monitoring well PL2-212A has demonstrated a 99.99+ percent reduction in TCE since the start of ERD treatment). The recommended changes to the monitoring plan are based on demonstrating compliance and collecting sufficient data for remedial optimization.

It is recommended that monitoring for dissolved gases cease; there are more than enough data to demonstrate that degradation past VC is occurring. It is also recommended that monitoring be discontinued at those groundwater wells that have been consistently clean, as their results are not useful for making decisions about the remaining plume and remedial action.

The existing wells sampled (from the initial monitoring plan) are listed in Table 4.1. The recommended wells for a revised sampling program are listed in Table 4.2. All monitoring wells are currently sampled on a quarterly basis. As CVOC concentrations continue to decline, the monitoring schedule may change to a semi-annual basis (a change that is not yet recommended at this time but is anticipated in the future). Refer to Figure 4.4 for the revised IM groundwater monitoring locations.

[4] The hydraulic conductivity (K) is estimated at 270 ft/day based on an aquifer pumping test. The gradient (i) has been measured at 0.001 feet per foot (tidally averaged), with a calculated groundwater pore velocity of 1.1 ft/day (based on K and i noted above, and a porosity of 25 percent).

**Table 4.1**
**2-10 IM Current Groundwater Monitoring List**

| Well ID | Well Description | Sample Analytes |
|---|---|---|
| North Sheetpile | | |
| PL2-212A | Monitoring well, near former degreaser | VOCs, MEE |
| IW-N-1 | Injection well, near former degreaser | VOCs, TOC |
| IW-N-4 | Injection well, center of treatment area | VOCs, TOC |
| IW-N-5 | Injection well, near former degreaser | VOCs, TOC |
| IW-N-6 | Injection well, near former degreaser | VOCs, TOC |
| PL2-218A | Monitoring well, shallow | VOCs, MEE |
| PL2-218B | Monitoring well, deep | VOCs, MEE |
| PL2-258A | Monitoring well, shoreline well, downgradient | VOCs |
| PL2-258B | Monitoring well, shoreline well, downgradient | VOCs |
| South Sheetpile | | |
| PL2-209A | Monitoring well, downgradient from former degreaser, shallow | VOCs |
| PL2-209B | Monitoring well, downgradient from former degreaser, deep | VOCs |
| PL2-257A | Monitoring well, outside sheetpile, upgradient | VOCs |
| PL2-256A | Monitoring well, inside sheetpile, upgradient | VOCs |
| PL2-253A | Monitoring well, inside sheetpile, downgradient | VOCs |
| IW-S-12 | Injection well, outside sheetpile | VOCs, TOC |
| IW-S-13 | Injection well, inside sheetpile | VOCs, TOC |

Abbreviations:

MEE Methane, ethane, ethene (Dissolved Gases)

TOC Total organic carbon

**Table 4.2**
**2-10 IM Revised Groundwater Monitoring List (Proposed)**

| Well ID | Well Description | Sample Analytes |
|---|---|---|
| North Sheetpile | | |
| PL2-212A | Monitoring well, near former degreaser | VOCs |
| IW-N-4 | Injection well, center of treatment area | VOCs, TOC |
| IW-N-6 | Injection well, near former degreaser | VOCs, TOC |
| PL2-218A | Monitoring well, shallow | VOCs |
| PL2-218B | Monitoring well, deep | VOCs |
| PL2-258A[1] | Monitoring well, shoreline well, downgradient | VOCs |
| PL2-258B[1] | Monitoring well, shoreline well, downgradient | VOCs |
| South Sheetpile | | |
| PL2-209A | Monitoring well, downgradient from former degreaser | VOCs |
| PL2-257A | Monitoring well, outside sheetpile, upgradient | VOCs |
| PL2-256A | Monitoring well, inside sheetpile, upgradient | VOCs |
| PL2-253A | Monitoring well, inside sheetpile, downgradient | VOCs |
| PL2-214A[1] | Monitoring well, outside sheetpile (downgradient of predicted flow path from PL2-257A, to be sampled twice a year) | VOCs |
| PL2-216A | Monitoring well, outside sheetpile (downgradient of predicted flow path from PL2-257A, to be sampled twice a year) | VOCs |

Note:

1 This well is part of existing shoreline monitoring program.

Abbreviation:

TOC Total organic carbon

# 5.0 Recommendations and Schedule

This technical memorandum recommends implementation of specific remedial optimization measures and USEPA approval of those measures is requested.

The recommended remedial optimization of the IMs includes the following steps:

1. Initiate the SVE rebound testing: USEPA approval for this remedial optimization step was received on June 19, 2014, the two SVE systems (both north and south sheetpile areas) were shut down with rebound testing started on June 23, 2014.
2. Complete revised or new UIC registration for the planned bio-augmentation wells.
3. Continue the ERD treatment of groundwater and include bio-augmentation in selected areas.
4. Modify the monitoring program (as listed in Table 4.2) and continue the monitoring/ remedial optimization.

The work to implement the recommended remedial optimization measures will begin within 45 days of USEPA approval. Depending on manufacturing/operations schedules in the 2-10 Building and required access for the remedial optimization work, some work may be delayed as necessary to accommodate existing manufacturing operations in the building.

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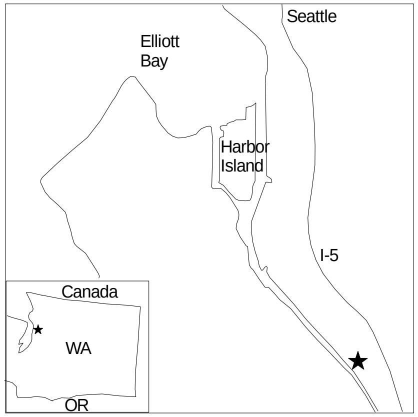
**Boeing Plant 2**
**Seattle/Tukwila, Washington**

# Remedial Optimization for the 2-10 Interim Measures

# Technical Memorandum

# Figures

**Agency Review Draft**


2-10 PLANT 2 BUILDING ID

PLANT 2 BOUNDARY (approx.)

APPROXIMATE SCALE IN FEET

0 250 500 1000

N

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Interim Measures
North and South Sheetpiles in the 2-10 Building
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Figure 1.1
Site Location Map
Building 2-10 IM

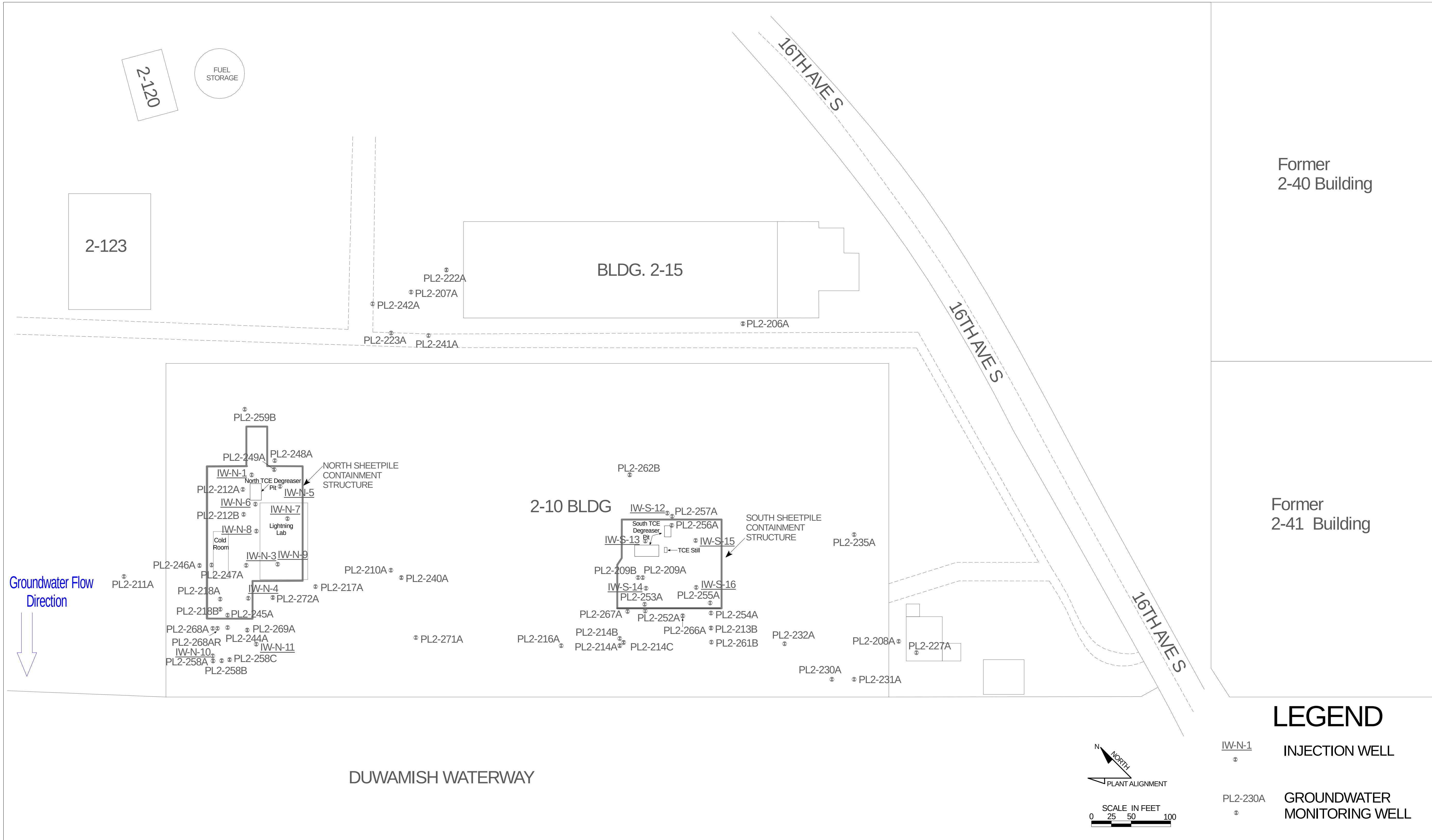


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Figure 1.2
Site Layout and Monitoring Wells
Building 2-10 IM

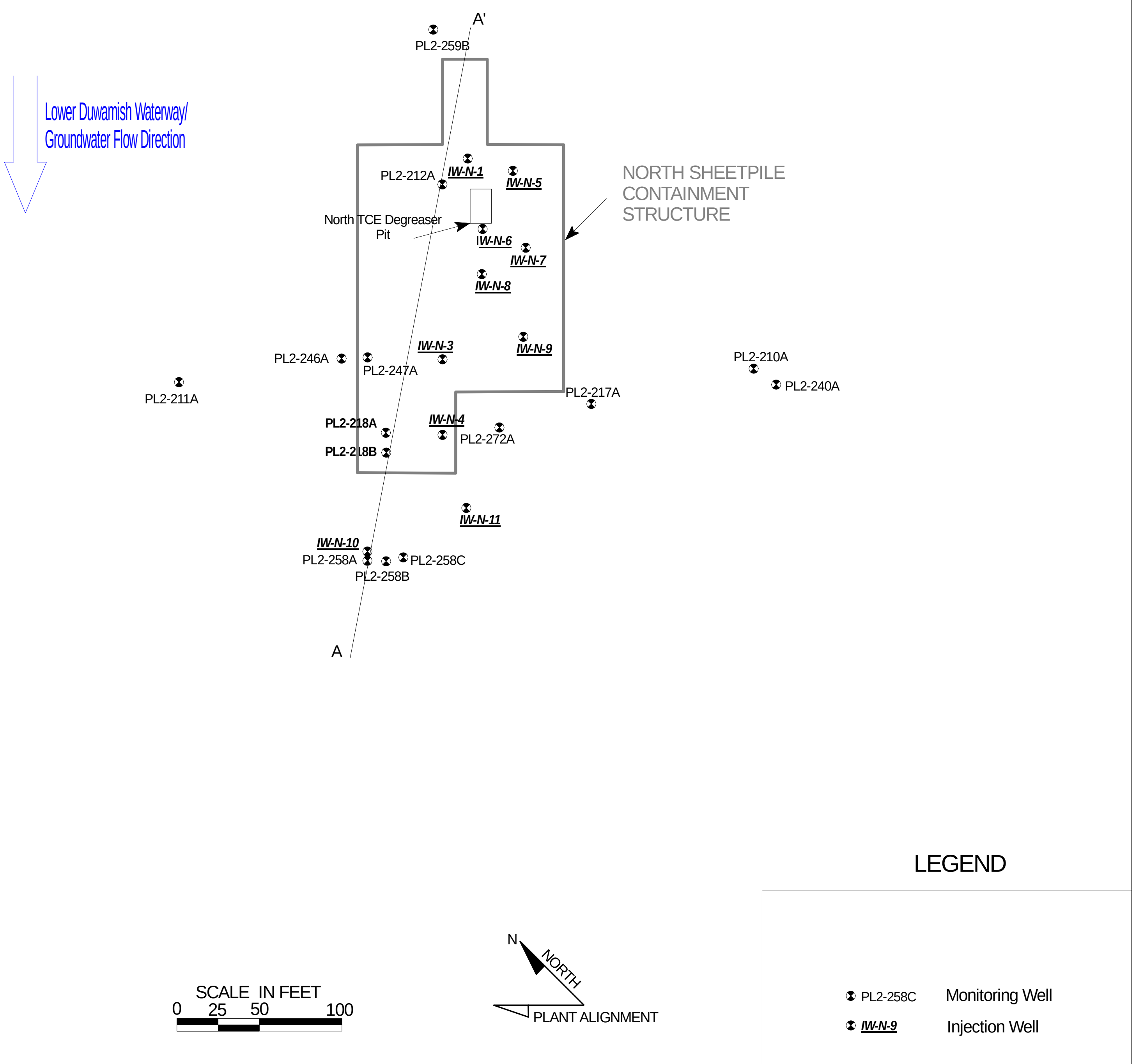


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Figure 1.3
North Sheetpile Area Monitoring and Injection Wells
Building 2-10 IM

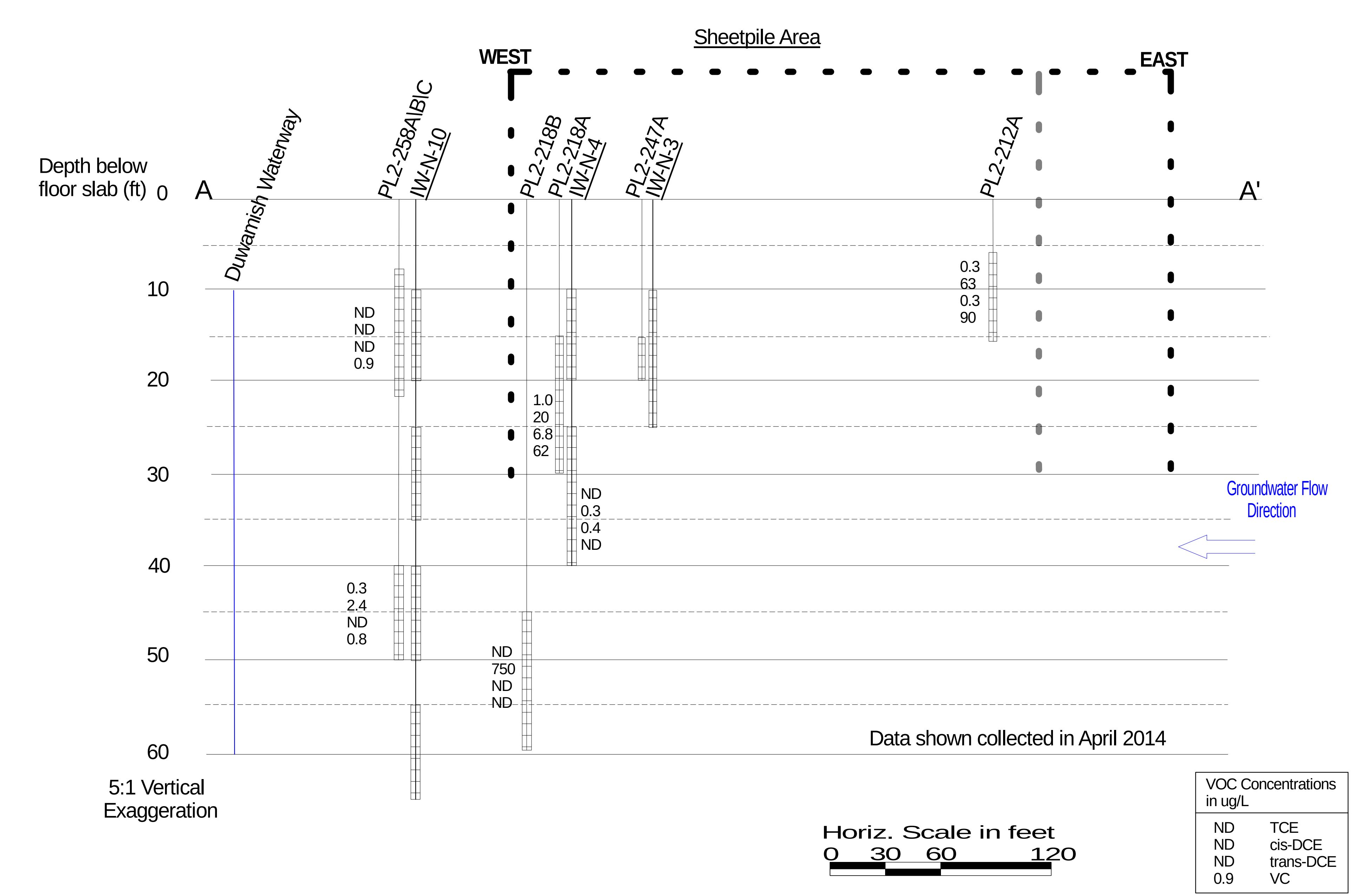


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Figure 1.4
Cross Section of North Sheetpile Area with Most Recent Monitoring Data - April 2014
Building 2-10 IM

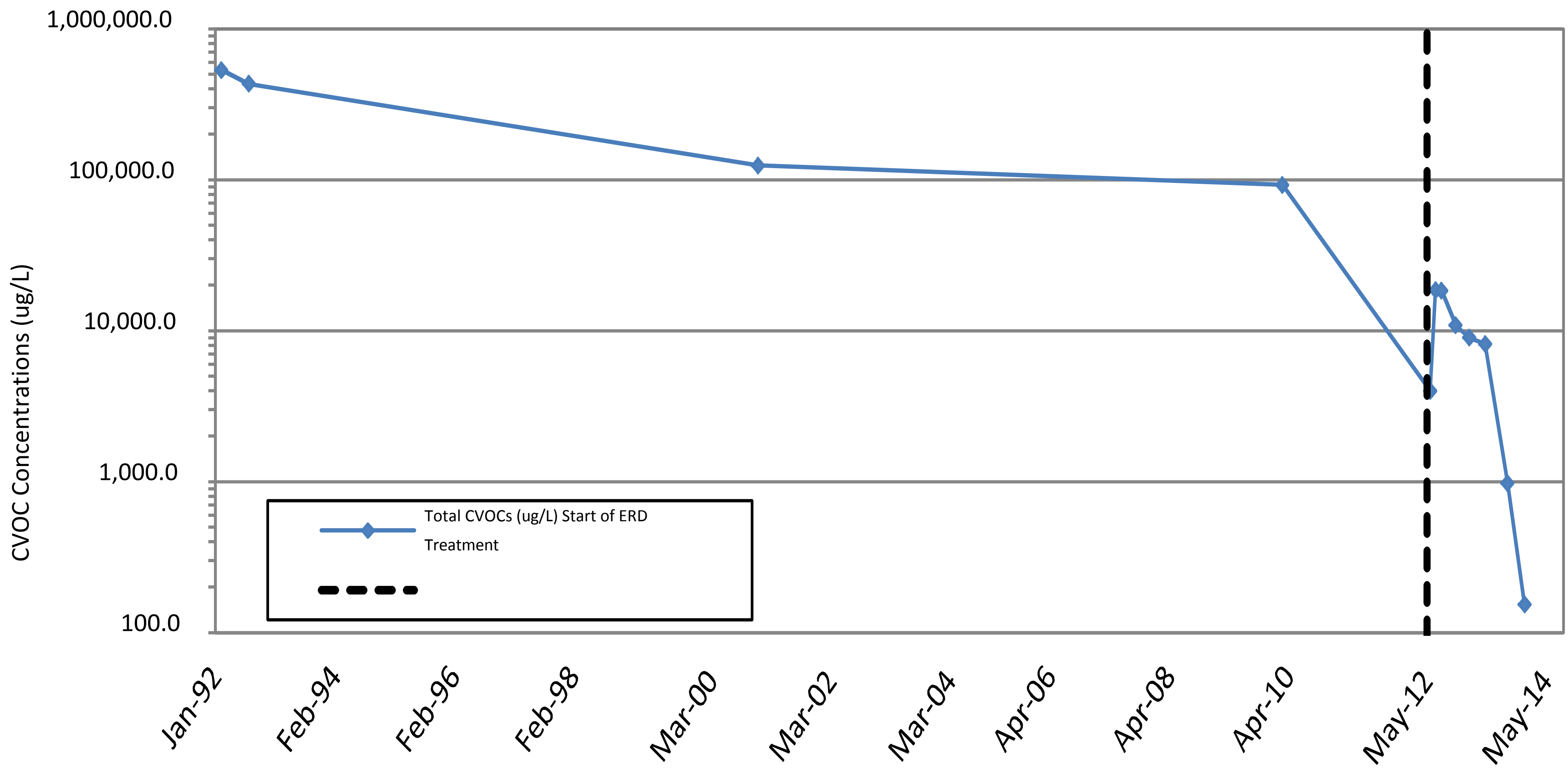


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Figure 1.5
Sum of CVOC
Concentrations Over Time
at Source Area Well
PL2-212A

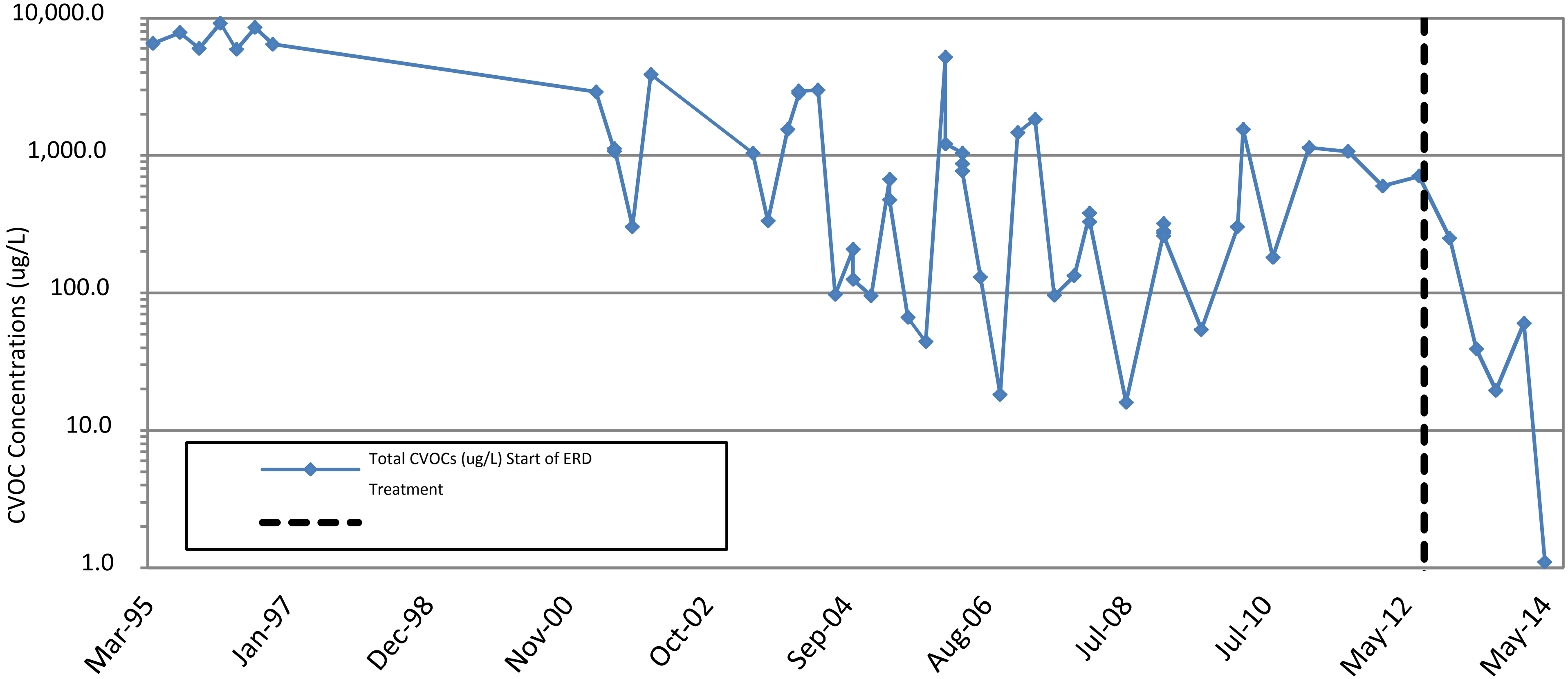


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Figure 1.6
Sum of CVOC
Concentrations Over
Time at Well PL2 - 258A

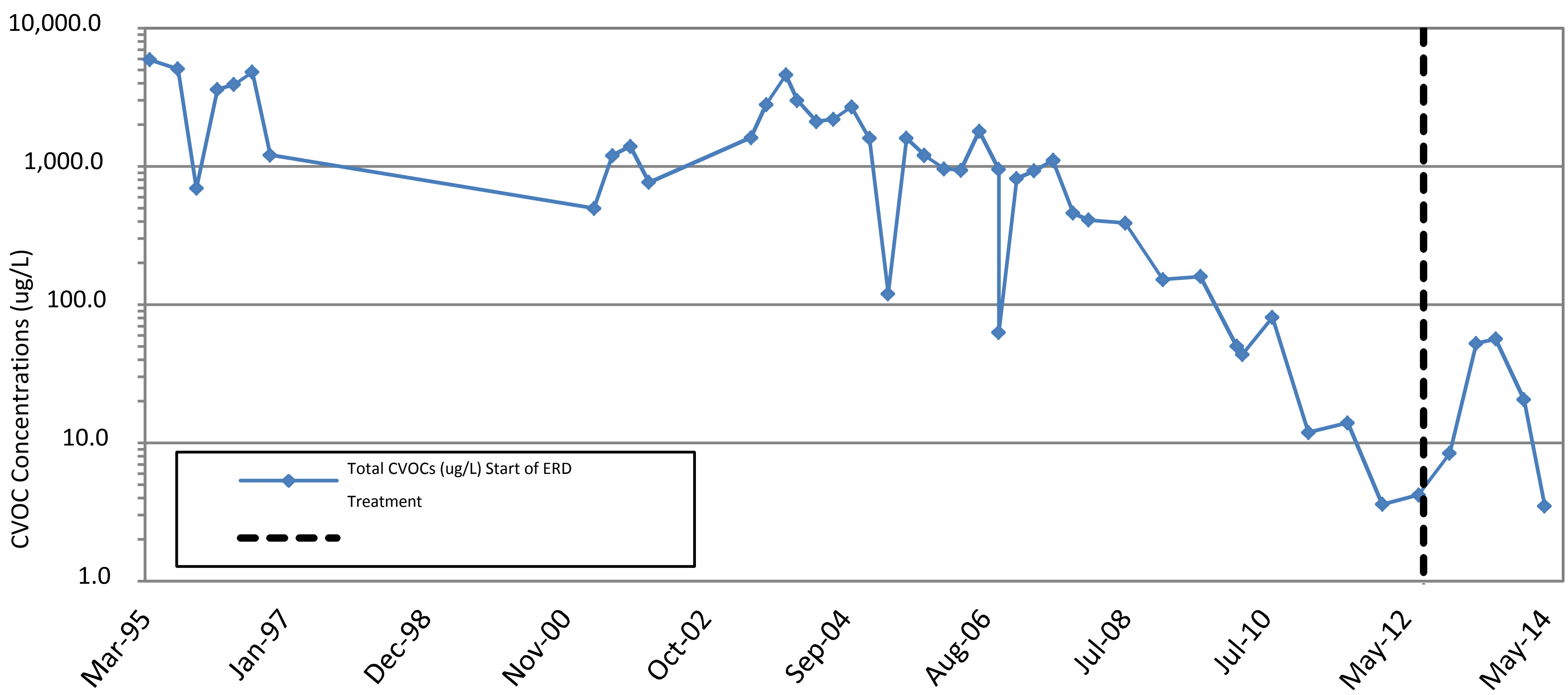


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Figure 1.7
Sum of CVOC Concentrations
Over Time at Well PL2-258B

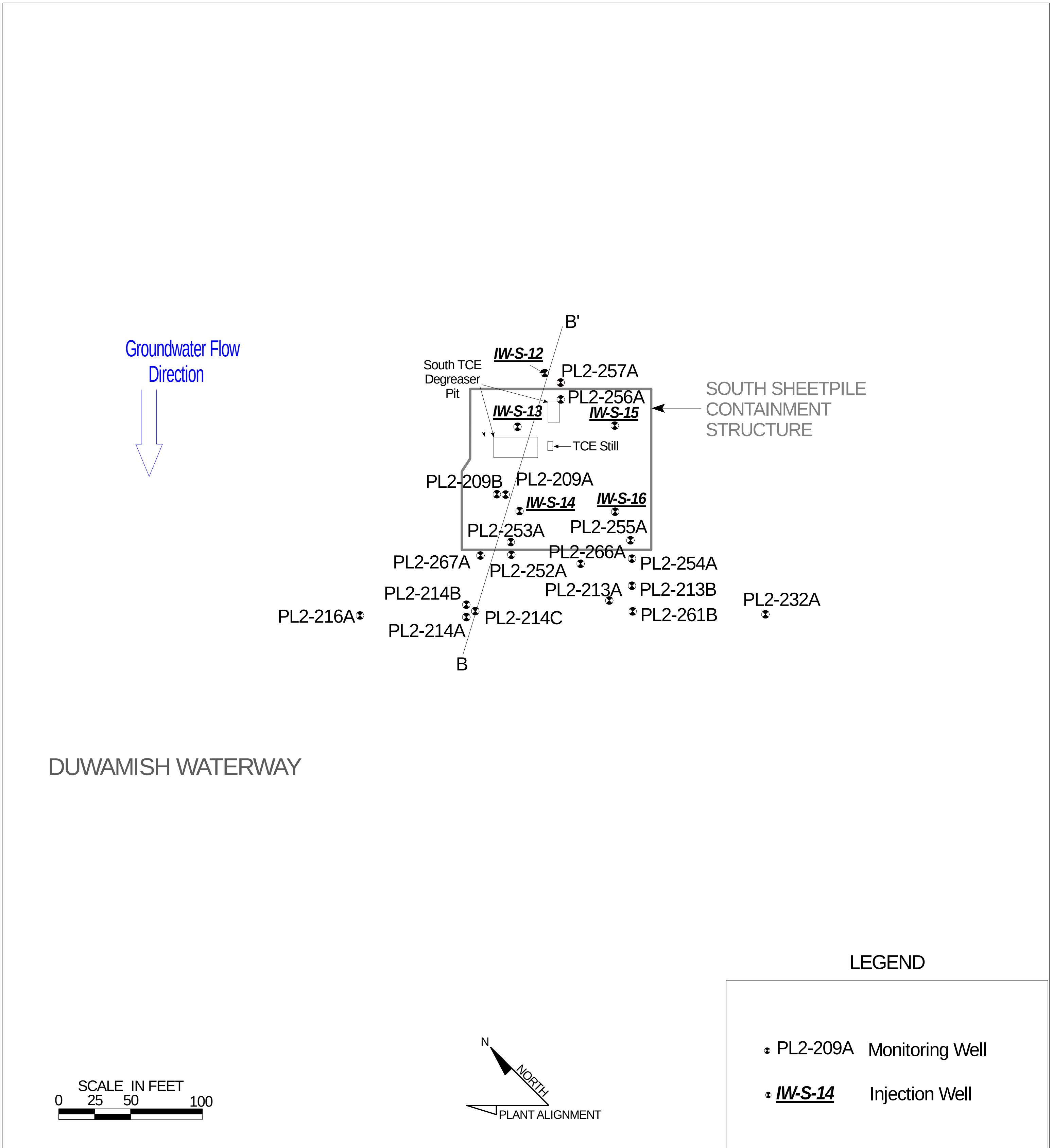


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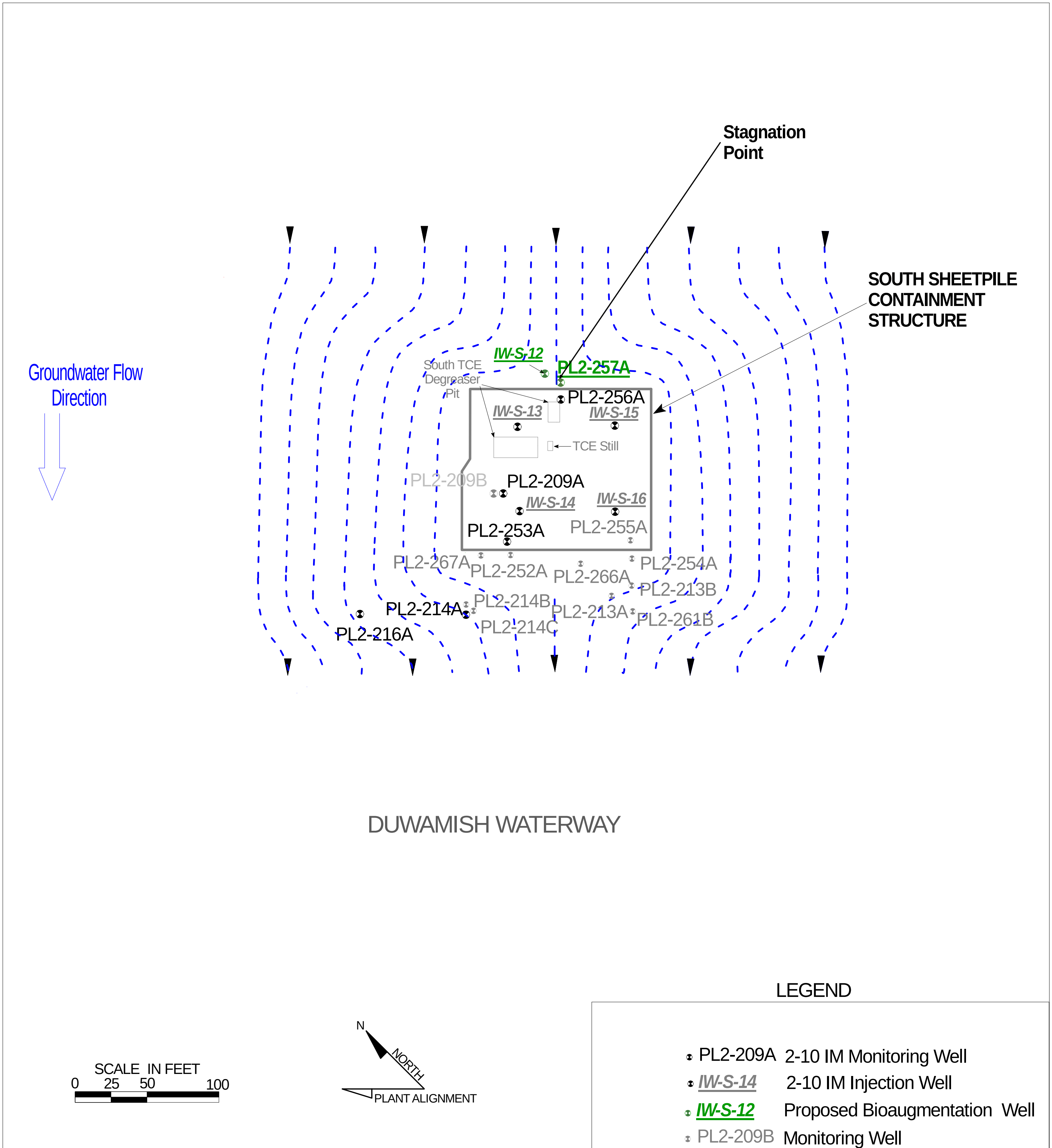
Figure 1.8
South Sheetpile Area Monitoring and Injection Wells
Building 2-10 IM

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Interim Measures
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Figure 1.9
Predicted Groundwater Flow Path
Around South Sheetpile Area
Building 2-10 IM

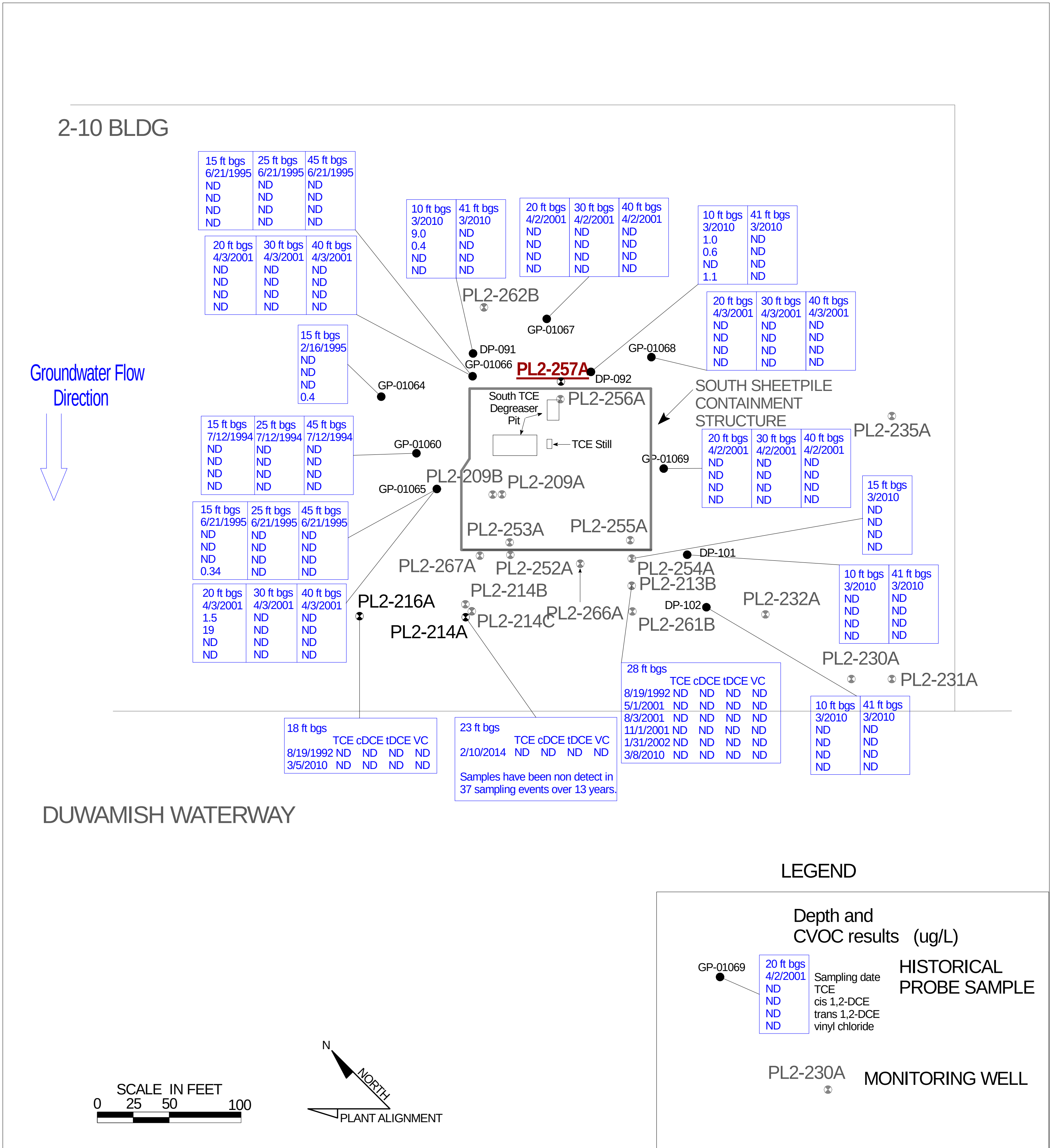


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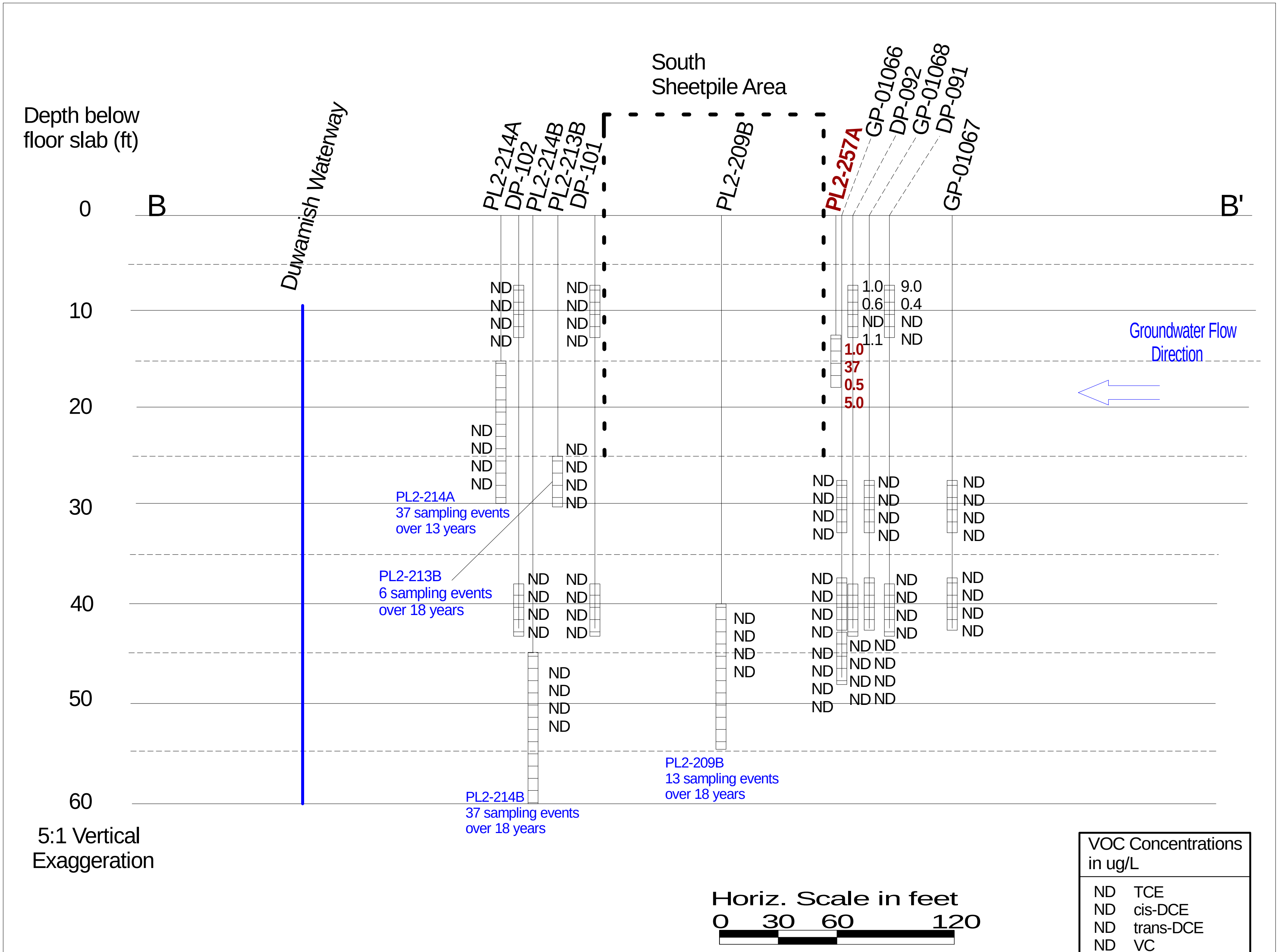
Figure 1.10
Plan View of South Sheetpile Area with Current and Historical Monitoring Data
Building 2-10 IM

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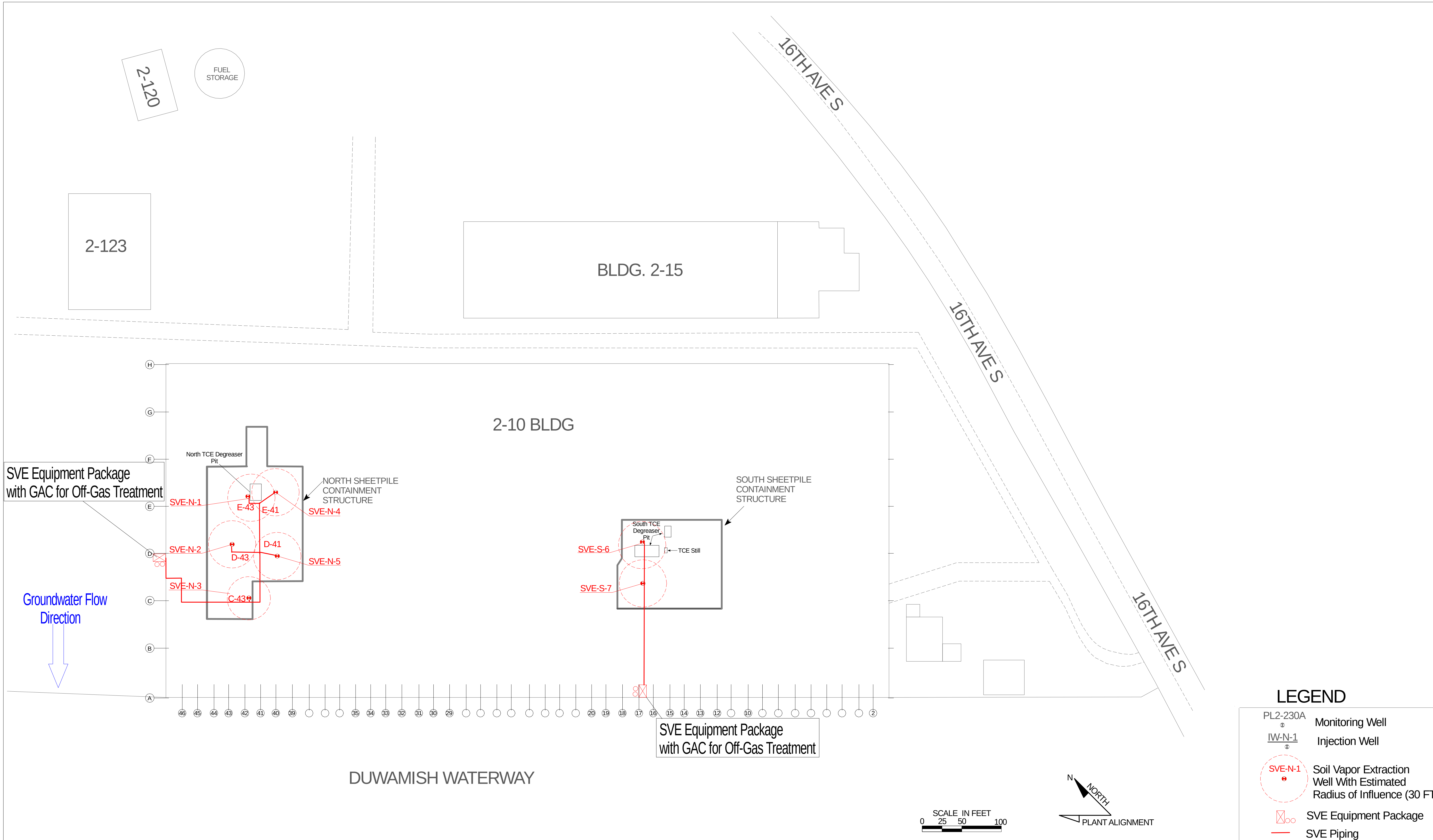
Interim Measures
South Sheetpile in the 2-10 Bldg
Boeing Plant 2
Seattle/Tukwila, Washington

Figure 1.11
Cross Section of South Sheetpile
Area with Current and Historical
Monitoring Data
Building 2-10 IM

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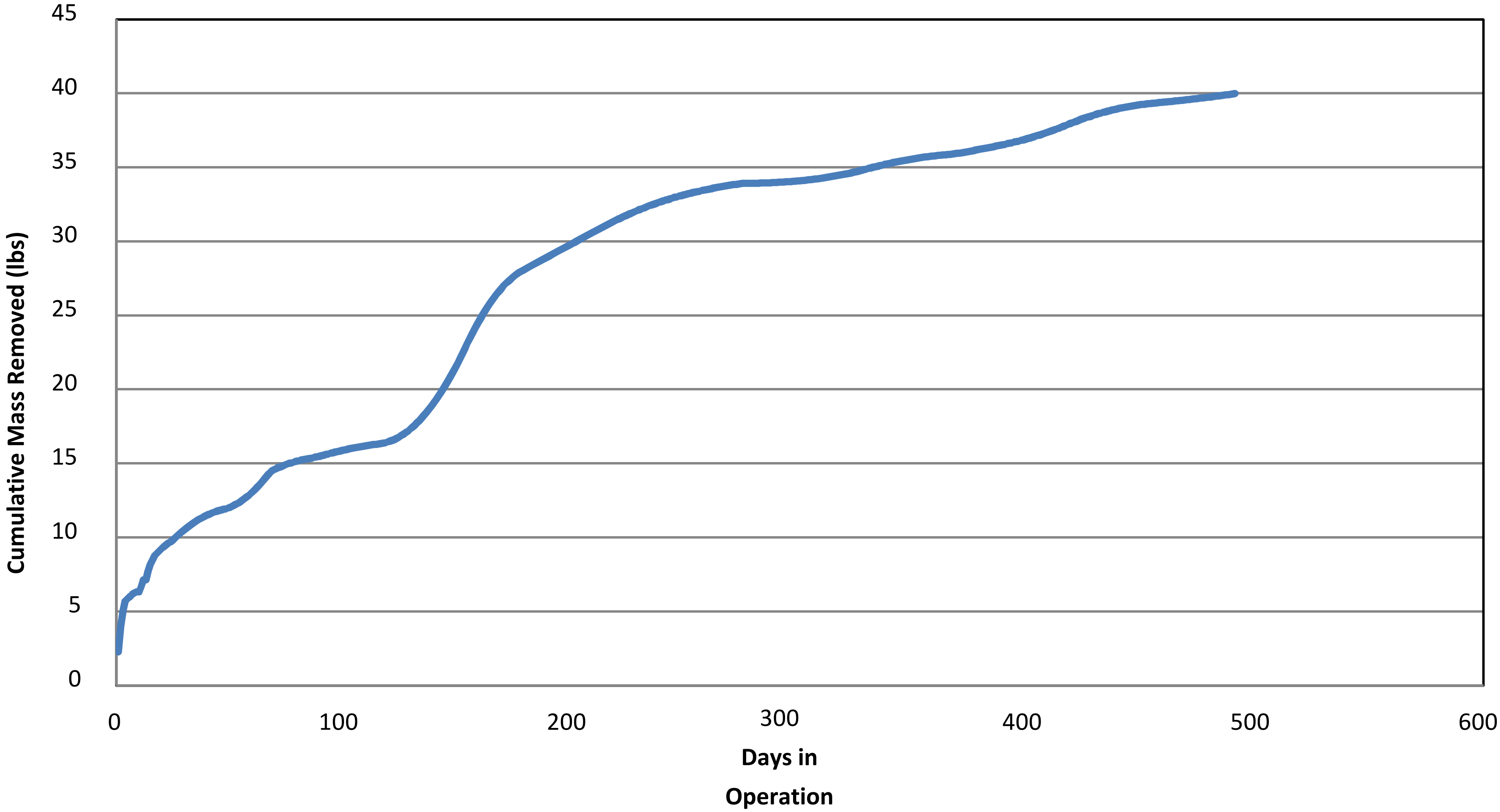
Interim Measures
North and South Sheetpiles in the 2-10 Building
Boeing Plant 2
Seattle/Tukwila, Washington

Figure 2.1
SVE Well Locations
Building 2-10 IM

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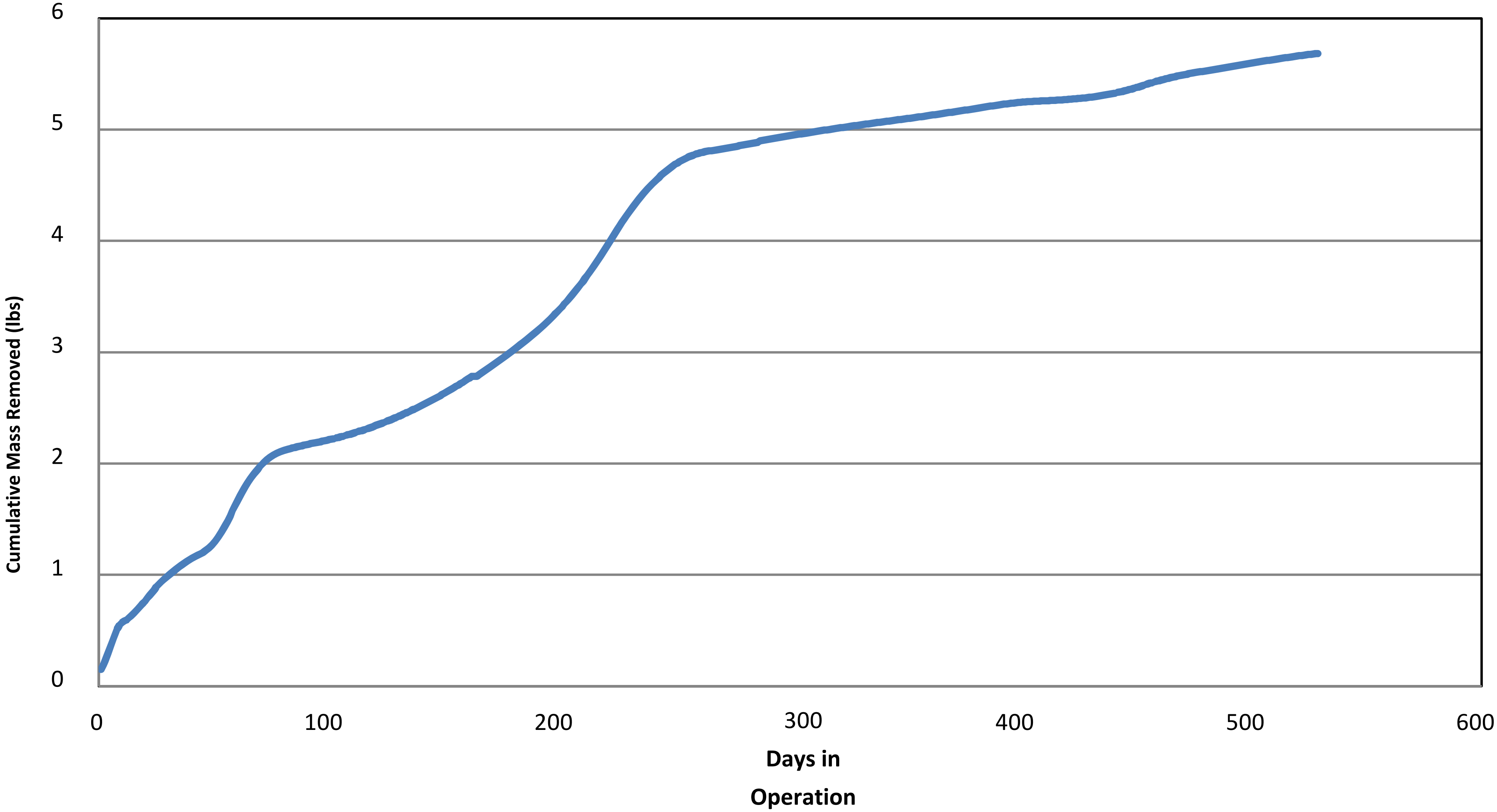
Interim Measures
North Sheetpile in the 2-10 Bldg
Boeing Plant 2
Seattle/Tukwila, Washington

Figure 2.2
Cumulative TCE Mass Removed From North SVE System

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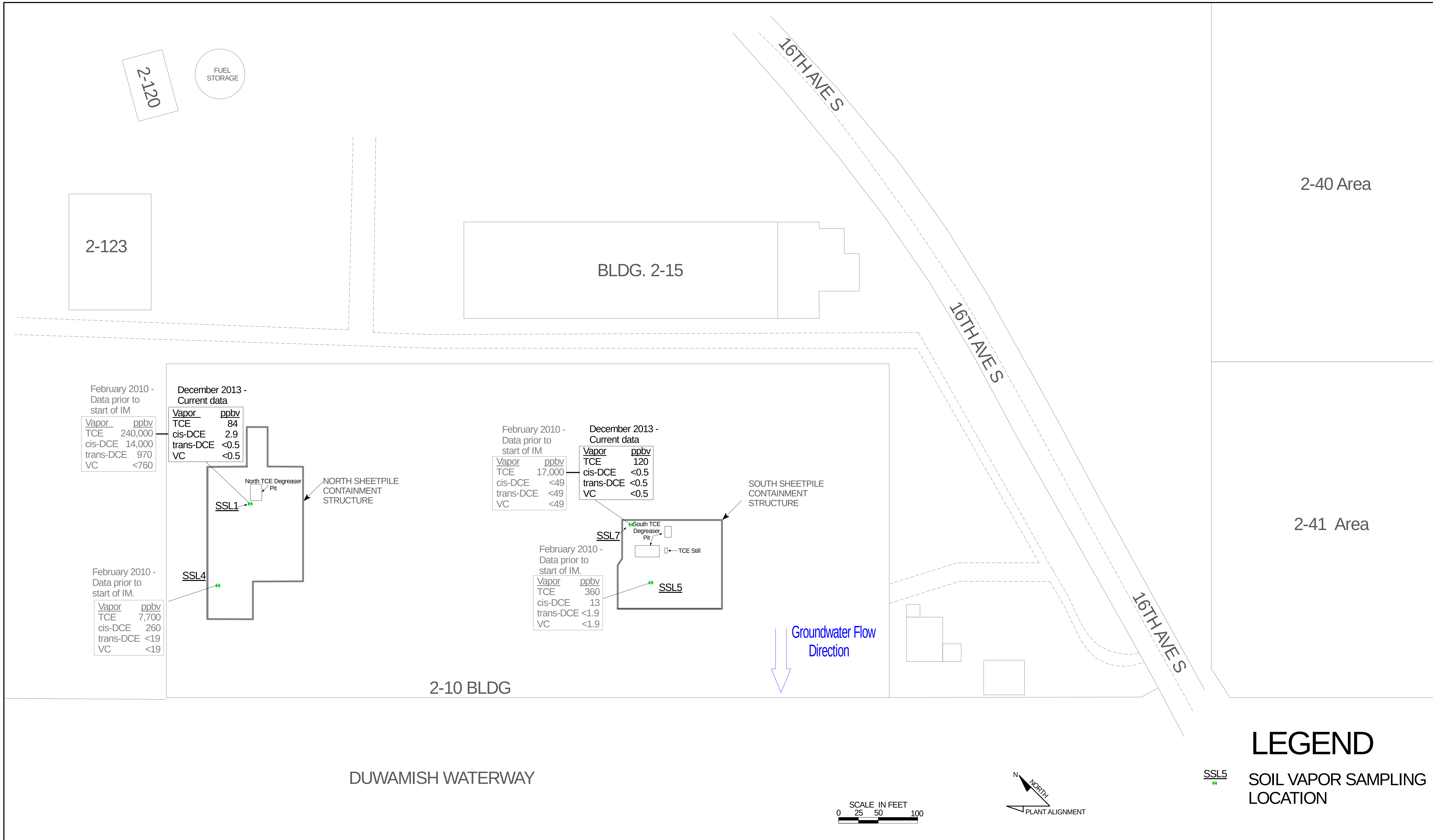
Interim Measures
North Sheetpile in the 2-10 Bldg
Boeing Plant 2
Seattle/Tukwila, Washington

Figure 2.3
Cumulative TCE Mass Removed
From South SVE System

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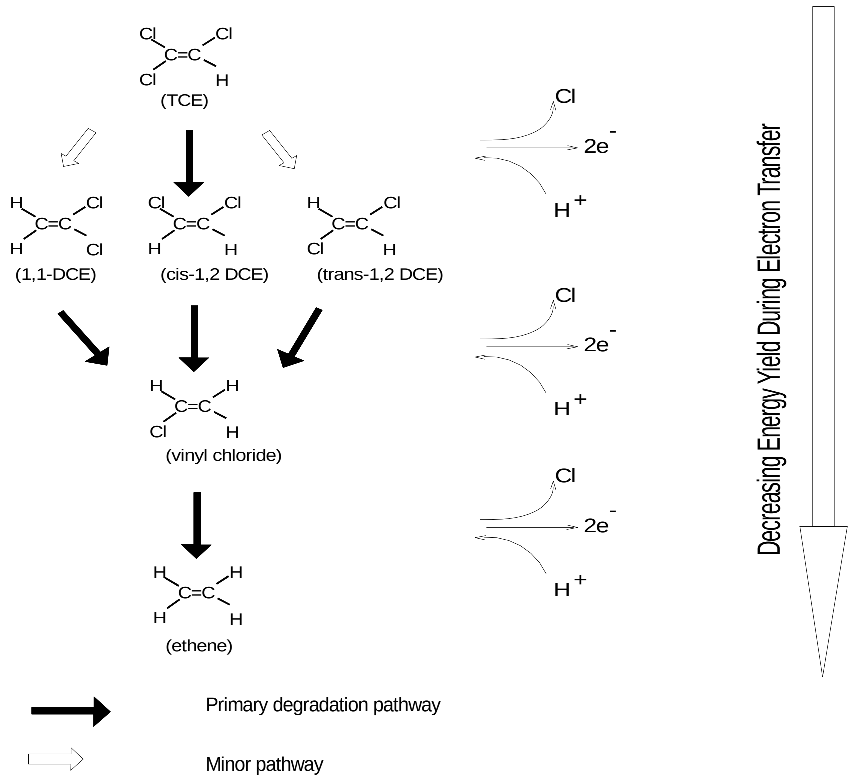
Interim Measures
North and South Sheetpiles in the 2-10 Building
Boeing Plant 2
Seattle/Tukwila, Washington

Figure 2.4
Soil Vapor Sampling Data,
North and South Sheetpiles
Building 2-10 IM

| Chlorinated Compound | Biologically- mediated reaction | Enabling Aquifer Condition | Typical Redox Energy Level for Optimum Degradation (see note below) |
|---|---|---|---|
| | | Anaerobic Denitrification | Redox measures +250 to +100 mV |
| | | Anaerobic Iron (III) reduction | Redox measures +100 to 0 mV |
| | | Anaerobic Sulfate reduction | Redox measures 0 to -200 mV |
| | | Methane fermentation Methanogenesis | Redox measures -200 mV and lower |




Note: a wide range of ORP values have been cited in prior studies; values presented here are general ranges from prior work

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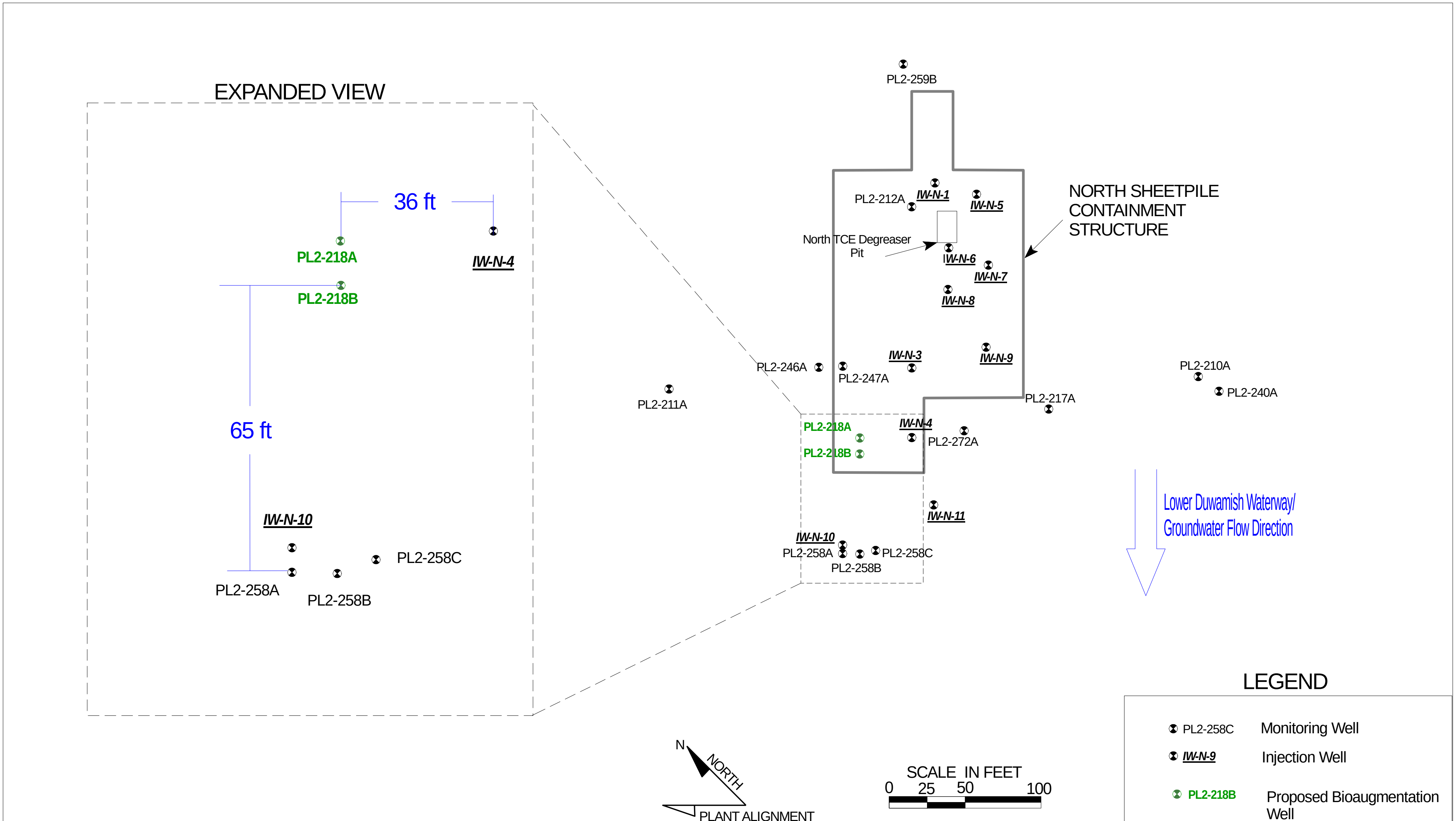
Interim Measures
North and South Sheetpiles in the 2-10 Building
Boeing Plant 2
Seattle/Tukwila, Washington

Figure 4.1
Biological Steps for Enhanced Reductive Dechlorination
Building 2-10 IM

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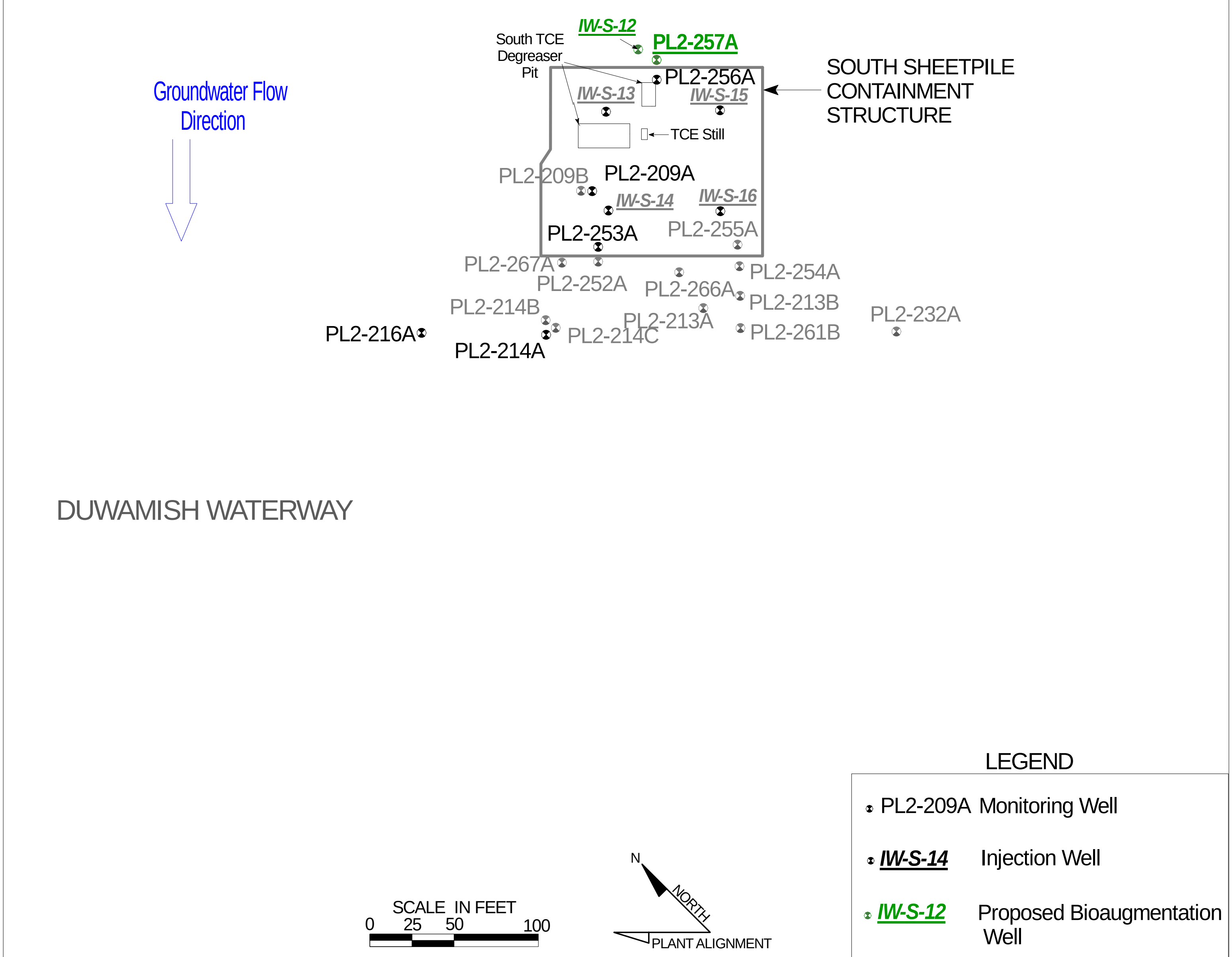
Interim Measures
North Sheetpiles in the 2-10 Bldg
Boeing Plant 2
Seattle/Tukwila, Washington

Figure 4.2
Planned Bioaugmentation Wells
North Sheetpile Area
Building 2-10 IM

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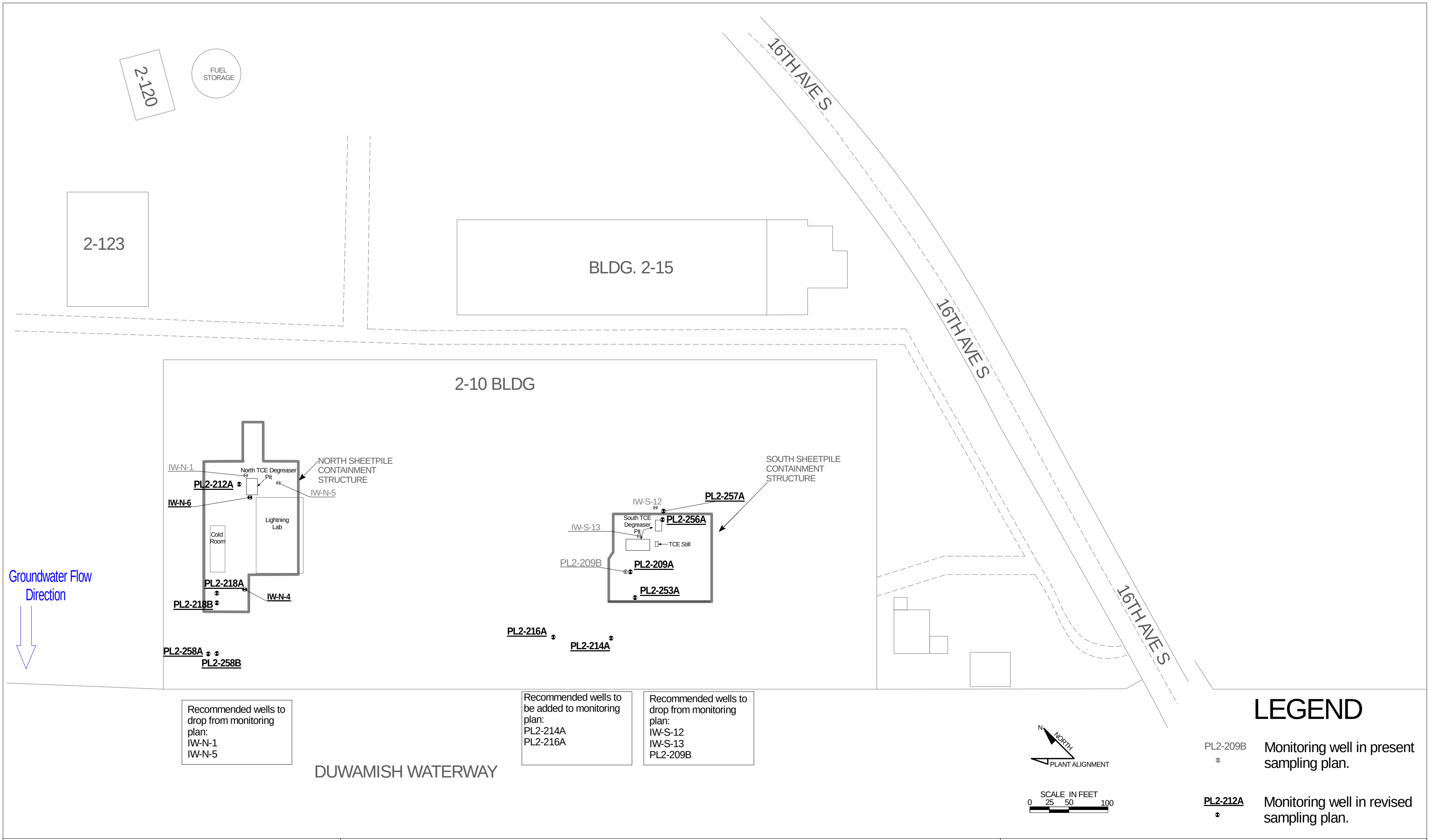
Interim Measures
South Sheetpile in the 2-10 Building
Boeing Plant 2
Seattle/Tukwila, Washington

Figure 4.3
Planned Bioaugmentation Wells
South Sheetpile Area
Building 2-10 IM

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Interim Measures
North and South Sheetpiles in the 2-10 Building
Boeing Plant 2
Seattle/Tukwila, Washington

Figure 4.4
Revised Groundwater Monitoring Plan
Building 2-10 IM

**Boeing Plant 2**
**Seattle/Tukwila, Washington**

# Remedial Optimization for the 2-10 Interim Measures

# Technical Memorandum

# Appendix A
# Performance Monitoring Data

**Agency Review Draft**

## North Sheetpile TCE Mass Removal Estimates and System Operation Data

| Date | PID Reading[1] (ppmv) | TCE Concentration[2] (ppmv) | Interpolated TCE Concentration[3] (ppmv) | Flow (cfm) | TCE Removed (lbs) | Days in Operation | Operational Notes |
|---|---|---|---|---|---|---|---|
| 1/14/2013 | **85.9** | 46.4 | 46.4 | 101 | 2.26 | 1 | Initial system startup. |
| | | | 35.8 | 101 | 1.74 | 2 | |
| | | | 25.2 | 88 | 1.07 | 3 | |
| | | | 14.6 | 88 | 0.62 | 4 | |
| 1/18/2013 | **7.3** | 4.0 | 4.0 | 83 | 0.16 | 5 | |
| | | | 3.6 | 83 | 0.14 | 6 | |
| | | | 3.2 | 83 | 0.13 | 7 | |
| | | | 2.8 | 83 | 0.11 | 8 | |
| 1/22/2013 | **4.5** | 2.4 | 2.4 | 83 | 0.10 | 9 | 2200. Adjusted system to run from bleed solely during substrate injection. |
| 1/28/2013 | | | | 83 | 0.00 | 10 | 1600. Reset system to again pull vapors from wells, substrate injection mounding has receded. |
| 1/29/2013 | **15.9** | 8.6 | 8.6 | 83 | 0.34 | 11 | |
| | | | 11.4 | 83 | 0.45 | 12 | |
| | | | | 0 | 0.00 | 13 | Unscheduled shutdown |
| 2/1/2013 | **26.2** | 14.1 | 14.1 | 83 | 0.57 | 14 | |
| | | | 11.6 | 83 | 0.47 | 15 | |
| | | | 9.1 | 83 | 0.37 | 16 | |
| | | | 6.6 | 83 | 0.27 | 17 | |
| 2/5/2013 | **7.6** | 4.1 | 4.1 | 83 | 0.16 | 18 | |
| | | | 3.8 | 83 | 0.15 | 19 | |
| | | | 3.6 | 83 | 0.14 | 20 | |
| | | | 3.3 | 83 | 0.13 | 21 | |
| | | | 3.0 | 83 | 0.12 | 22 | |
| | | | 2.7 | 83 | 0.11 | 23 | |
| | | | 2.4 | 83 | 0.10 | 24 | |
| 2/12/2013 | **3.96** | 2.1 | 2.1 | 141 | 0.15 | 25 | Interchanged pulleys on motor and blower to increase the blower speed and increase airflow. |
| | | | 2.1 | 141 | 0.14 | 26 | |
| | | | 2.0 | 141 | 0.14 | 27 | |
| | | | 2.0 | 141 | 0.13 | 28 | |
| | | | 1.9 | 141 | 0.13 | 29 | |
| | | | 1.9 | 141 | 0.13 | 30 | |
| | | | 1.8 | 141 | 0.12 | 31 | |
| | | | 1.7 | 141 | 0.12 | 32 | |
| | | | 1.7 | 141 | 0.12 | 33 | |
| 2/21/2013 | **3.03** | 1.6 | 1.6 | 135 | 0.11 | 34 | |
| | | | 1.6 | 135 | 0.10 | 35 | |
| | | | 1.5 | 135 | 0.10 | 36 | |
| | | | 1.4 | 135 | 0.09 | 37 | |
| | | | 1.3 | 135 | 0.09 | 38 | |
| | | | 1.2 | 135 | 0.08 | 39 | |
| | | | 1.1 | 135 | 0.07 | 40 | |
| | | | 1.1 | 135 | 0.07 | 41 | |
| | | | 1.0 | 135 | 0.06 | 42 | |
| | | | 0.9 | 135 | 0.06 | 43 | |
| | | | 0.8 | 135 | 0.05 | 44 | |
| | | | 0.7 | 135 | 0.05 | 45 | |
| | | | 0.6 | 135 | 0.04 | 46 | |
| 3/6/2013 | **1.05** | 0.6 | 0.6 | 130 | 0.04 | 47 | |
| | | | 0.7 | 135 | 0.04 | 48 | |
| | | | 0.8 | 135 | 0.05 | 49 | |
| | | | 0.9 | 135 | 0.06 | 50 | |
| | | | 1.1 | 135 | 0.07 | 51 | |
| | | | 1.2 | 135 | 0.08 | 52 | |
| | | | 1.3 | 135 | 0.09 | 53 | |
| | | | 1.4 | 135 | 0.09 | 54 | |
| | | | 1.6 | 135 | 0.10 | 55 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1.7 | 135 | 0.11 | 56 | |
| | | | 1.8 | 135 | 0.12 | 57 | |
| | | | 1.9 | 135 | 0.13 | 58 | |
| | | | 2.1 | 135 | 0.13 | 59 | |
| | | | 2.2 | 135 | 0.14 | 60 | |
| | | | 2.3 | 135 | 0.15 | 61 | |
| | | | 2.4 | 135 | 0.16 | 62 | |
| | | | 2.6 | 135 | 0.17 | 63 | |
| | | | 2.7 | 135 | 0.17 | 64 | |
| | | | 2.8 | 135 | 0.18 | 65 | |
| 3/25/2013 | **5.44** | 2.9 | 2.9 | 135 | 0.19 | 66 | |
| | | | 2.6 | 135 | 0.17 | 67 | |
| | | | 2.2 | 135 | 0.14 | 68 | |
| | | | 1.8 | 135 | 0.12 | 69 | |
| | | | 1.4 | 135 | 0.09 | 70 | |
| 4/2/2013 | **1.89** | 1.0 | 1.0 | 135 | 0.07 | 71 | |
| | | | 1.0 | 135 | 0.06 | 72 | |
| | | | 0.9 | 135 | 0.06 | 73 | |
| | | | 0.9 | 135 | 0.06 | 74 | |
| | | | 0.8 | 135 | 0.05 | 75 | |
| | | | 0.8 | 135 | 0.05 | 76 | |
| | | | 0.8 | 135 | 0.05 | 77 | |
| | | | 0.7 | 135 | 0.05 | 78 | |
| | | | 0.7 | 135 | 0.04 | 79 | |
| | | | 0.6 | 135 | 0.04 | 80 | |
| | | | 0.6 | 135 | 0.04 | 81 | |
| | | | 0.5 | 135 | 0.04 | 82 | |
| | | | 0.5 | 135 | 0.03 | 83 | |
| 4/15/2013 | **0.83** | 0.5 | 0.5 | 135 | 0.03 | 84 | |
| | | | 0.5 | 135 | 0.03 | 85 | |
| | | | 0.5 | 135 | 0.03 | 86 | |
| | | | 0.5 | 135 | 0.03 | 87 | |
| | | | 0.5 | 135 | 0.03 | 88 | |
| | | | 0.5 | 135 | 0.04 | 89 | Construction Report |
| | | | 0.6 | 135 | 0.04 | 90 | |
| | | | 0.6 | 135 | 0.04 | 91 | |
| | | | 0.6 | 135 | 0.04 | 92 | |
| | | | 0.6 | 135 | 0.04 | 93 | |
| 4/25/2013 | **1.20** | 0.6 | 0.6 | 135 | 0.04 | 94 | |
| | | | 0.6 | 135 | 0.04 | 95 | |
| | | | 0.6 | 135 | 0.04 | 96 | |
| | | | 0.6 | 135 | 0.04 | 97 | |
| | | | 0.6 | 135 | 0.04 | 98 | |
| | | | 0.6 | 135 | 0.04 | 99 | |
| | | | 0.5 | 135 | 0.04 | 100 | |
| | | | 0.5 | 135 | 0.03 | 101 | |
| | | | 0.5 | 135 | 0.03 | 102 | |
| | | | 0.5 | 135 | 0.03 | 103 | |
| | | | 0.5 | 135 | 0.03 | 104 | |
| | | | 0.5 | 135 | 0.03 | 105 | |
| | | | 0.4 | 135 | 0.03 | 106 | |
| | | | 0.4 | 135 | 0.03 | 107 | |
| | | | 0.4 | 135 | 0.03 | 108 | |
| 5/10/2013 | **17.30** | 9.3 | 0.4 | 135 | 0.03 | 109 | Reading is not concurrent with other readings, not used for mass removal estimate. |
| | | | 0.4 | 135 | 0.02 | 110 | |
| | | | 0.4 | 135 | 0.02 | 111 | |
| | | | 0.3 | 135 | 0.02 | 112 | |
| | | | 0.3 | 135 | 0.02 | 113 | |
| | | | 0.3 | 135 | 0.02 | 114 | |
| | | | 0.3 | 135 | 0.02 | 115 | |
| 5/17/2013 | **0.53** | 0.3 | 0.3 | 135 | 0.02 | 116 | |
| | | | 0.4 | 135 | 0.03 | 117 | |
| | | | 0.5 | 135 | 0.03 | 118 | |
| | | | 0.7 | 135 | 0.04 | 119 | |
| | | | 0.8 | 135 | 0.05 | 120 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0.9 | 135 | 0.06 | 121 | |
| | | | 1.0 | 135 | 0.07 | 122 | |
| | | | 1.2 | 135 | 0.08 | 123 | |
| | | | 1.3 | 135 | 0.08 | 124 | |
| | | | 1.4 | 135 | 0.09 | 125 | |
| | | | 1.5 | 135 | 0.10 | 126 | |
| | | | 1.7 | 135 | 0.11 | 127 | |
| | | | 1.8 | 135 | 0.12 | 128 | |
| | | | 1.9 | 135 | 0.12 | 129 | |
| | | | 2.0 | 135 | 0.13 | 130 | |
| | | | 2.2 | 135 | 0.14 | 131 | |
| | | | 2.3 | 135 | 0.15 | 132 | |
| | | | 2.4 | 135 | 0.16 | 133 | |
| | | | 2.5 | 135 | 0.17 | 134 | |
| | | | 2.7 | 135 | 0.17 | 135 | |
| | | | 2.8 | 135 | 0.18 | 136 | |
| | | | 2.9 | 135 | 0.19 | 137 | |
| | | | 3.0 | 135 | 0.20 | 138 | |
| | | | 3.2 | 135 | 0.21 | 139 | |
| | | | 3.3 | 135 | 0.21 | 140 | |
| | | | 3.4 | 135 | 0.22 | 141 | |
| | | | 3.5 | 135 | 0.23 | 142 | |
| | | | 3.7 | 135 | 0.24 | 143 | |
| | | | 3.8 | 135 | 0.25 | 144 | |
| | | | 3.9 | 135 | 0.25 | 145 | |
| | | | 4.0 | 135 | 0.26 | 146 | |
| | | | 4.2 | 135 | 0.27 | 147 | |
| | | | 4.3 | 135 | 0.28 | 148 | |
| | | | 4.4 | 135 | 0.29 | 149 | |
| | | | 4.5 | 135 | 0.30 | 150 | |
| | | | 4.7 | 135 | 0.30 | 151 | |
| | | | 4.8 | 135 | 0.31 | 152 | |
| | | | 4.9 | 135 | 0.32 | 153 | |
| 6/24/2013 | **9.33** | 5.0 | 5.0 | 135 | 0.33 | 154 | |
| | | | 4.9 | 135 | 0.32 | 155 | |
| | | | 4.7 | 135 | 0.31 | 156 | |
| | | | 4.6 | 135 | 0.30 | 157 | |
| | | | 4.4 | 135 | 0.29 | 158 | |
| | | | 4.3 | 135 | 0.28 | 159 | |
| | | | 4.1 | 135 | 0.27 | 160 | |
| | | | 4.0 | 135 | 0.26 | 161 | |
| | | | 3.8 | 135 | 0.25 | 162 | |
| | | | 3.7 | 135 | 0.24 | 163 | |
| | | | 3.5 | 135 | 0.23 | 164 | |
| | | | 3.4 | 135 | 0.22 | 165 | |
| | | | 3.2 | 135 | 0.21 | 166 | |
| | | | 3.1 | 135 | 0.20 | 167 | |
| | | | 2.9 | 135 | 0.19 | 168 | |
| | | | 2.8 | 135 | 0.18 | 169 | |
| | | | 2.6 | 135 | 0.17 | 170 | |
| | | | 2.5 | 135 | 0.16 | 171 | |
| | | | 2.3 | 135 | 0.15 | 172 | |
| | | | 2.2 | 135 | 0.14 | 173 | |
| | | | 2.0 | 135 | 0.13 | 174 | |
| | | | 1.9 | 135 | 0.12 | 175 | |
| | | | 1.7 | 135 | 0.11 | 176 | |
| | | | 1.6 | 135 | 0.10 | 177 | |
| | | | 1.4 | 135 | 0.09 | 178 | |
| 7/19/2013 | **2.38** | 1.3 | 1.3 | 135 | 0.08 | 179 | |
| | | | 1.3 | 135 | 0.08 | 180 | |
| | | | 1.3 | 135 | 0.08 | 181 | |
| | | | 1.3 | 135 | 0.08 | 182 | |
| | | | 1.3 | 135 | 0.08 | 183 | |
| | | | 1.3 | 135 | 0.08 | 184 | |
| | | | 1.3 | 135 | 0.08 | 185 | |
| | | | 1.3 | 135 | 0.08 | 186 | |
| | | | 1.3 | 135 | 0.08 | 187 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1.3 | 135 | 0.08 | 188 | |
| | | | 1.3 | 135 | 0.08 | 189 | |
| | | | 1.3 | 135 | 0.08 | 190 | |
| | | | 1.3 | 135 | 0.08 | 191 | |
| | | | 1.3 | 135 | 0.08 | 192 | |
| | | | 1.3 | 135 | 0.08 | 193 | |
| | | | 1.3 | 135 | 0.08 | 194 | |
| | | | 1.3 | 135 | 0.08 | 195 | |
| | | | 1.3 | 135 | 0.08 | 196 | |
| | | | 1.3 | 135 | 0.08 | 197 | |
| | | | 1.3 | 135 | 0.08 | 198 | |
| | | | 1.3 | 135 | 0.08 | 199 | |
| | | | 1.3 | 135 | 0.08 | 200 | |
| | | | 1.3 | 135 | 0.08 | 201 | |
| | | | 1.3 | 135 | 0.08 | 202 | |
| | | | 1.3 | 135 | 0.08 | 203 | |
| | | | 1.3 | 135 | 0.08 | 204 | |
| | | | 1.3 | 135 | 0.08 | 205 | |
| | | | 1.3 | 135 | 0.08 | 206 | |
| | | | 1.3 | 135 | 0.08 | 207 | |
| | | | 1.3 | 135 | 0.08 | 208 | |
| | | | 1.3 | 135 | 0.08 | 209 | |
| | | | 1.3 | 135 | 0.08 | 210 | |
| | | | 1.3 | 135 | 0.08 | 211 | |
| | | | 1.3 | 135 | 0.08 | 212 | |
| 8/22/2013 | **2.37** | 1.3 | 1.3 | 135 | 0.08 | 213 | |
| | | | 1.3 | 135 | 0.08 | 214 | |
| | | | 1.2 | 135 | 0.08 | 215 | |
| | | | 1.2 | 135 | 0.08 | 216 | |
| | | | 1.2 | 135 | 0.08 | 217 | |
| | | | 1.2 | 135 | 0.08 | 218 | |
| | | | 1.2 | 135 | 0.08 | 219 | |
| | | | 1.2 | 135 | 0.07 | 220 | |
| | | | 1.1 | 135 | 0.07 | 221 | |
| | | | 1.1 | 135 | 0.07 | 222 | |
| | | | 1.1 | 135 | 0.07 | 223 | |
| | | | 1.1 | 135 | 0.07 | 224 | |
| | | | 1.1 | 135 | 0.07 | 225 | |
| | | | 1.0 | 135 | 0.07 | 226 | |
| | | | 1.0 | 135 | 0.07 | 227 | |
| | | | 1.0 | 135 | 0.07 | 228 | |
| | | | 1.0 | 135 | 0.06 | 229 | |
| | | | 1.0 | 135 | 0.06 | 230 | |
| | | | 1.0 | 135 | 0.06 | 231 | |
| | | | 0.9 | 135 | 0.06 | 232 | |
| | | | 0.9 | 135 | 0.06 | 233 | |
| | | | 0.9 | 135 | 0.06 | 234 | |
| | | | 0.9 | 135 | 0.06 | 235 | |
| | | | 0.9 | 135 | 0.06 | 236 | |
| | | | 0.8 | 135 | 0.05 | 237 | |
| | | | 0.8 | 135 | 0.05 | 238 | |
| | | | 0.8 | 135 | 0.05 | 239 | |
| | | | 0.8 | 135 | 0.05 | 240 | |
| | | | 0.8 | 135 | 0.05 | 241 | |
| | | | 0.8 | 135 | 0.05 | 242 | |
| | | | 0.7 | 135 | 0.05 | 243 | |
| | | | 0.7 | 135 | 0.05 | 244 | |
| | | | 0.7 | 135 | 0.05 | 245 | |
| | | | 0.7 | 135 | 0.04 | 246 | |
| | | | 0.7 | 135 | 0.04 | 247 | |
| | | | 0.6 | 135 | 0.04 | 248 | |
| | | | 0.6 | 135 | 0.04 | 249 | |
| | | | 0.6 | 135 | 0.04 | 250 | |
| | | | 0.6 | 135 | 0.04 | 251 | |
| | | | 0.6 | 135 | 0.04 | 252 | |
| 10/1/2013 | **1.03** | 0.6 | 0.6 | 135 | 0.04 | 253 | |
| | | | 0.5 | 135 | 0.04 | 254 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 0.5 | 135 | 0.03 | 255 | |
| | | | 0.5 | 135 | 0.03 | 256 | |
| | | | 0.5 | 135 | 0.03 | 257 | |
| | | | 0.5 | 135 | 0.03 | 258 | |
| | | | 0.5 | 135 | 0.03 | 259 | |
| | | | 0.5 | 135 | 0.03 | 260 | |
| | | | 0.5 | 135 | 0.03 | 261 | |
| | | | 0.5 | 135 | 0.03 | 262 | |
| | | | 0.5 | 135 | 0.03 | 263 | |
| | | | 0.4 | 135 | 0.03 | 264 | |
| | | | 0.4 | 135 | 0.03 | 265 | |
| | | | 0.4 | 135 | 0.03 | 266 | |
| | | | 0.4 | 135 | 0.03 | 267 | |
| | | | 0.4 | 135 | 0.03 | 268 | |
| | | | 0.4 | 135 | 0.03 | 269 | |
| | | | 0.4 | 135 | 0.03 | 270 | |
| | | | 0.4 | 135 | 0.02 | 271 | |
| | | | 0.4 | 135 | 0.02 | 272 | |
| | | | 0.4 | 135 | 0.02 | 273 | |
| | | | 0.3 | 135 | 0.02 | 274 | |
| 10/23/2013 | **0.34** | 0.3 | 0.3 | 135 | 0.02 | 275 | Tedlar bag Sample |
| 10/24/2013 | **0.00** | 0.0 | 0.0 | 135 | 0.00 | 276 | |
| | | | 0.0 | 135 | 0.00 | 277 | |
| | | | 0.0 | 135 | 0.00 | 278 | |
| | | | 0.0 | 135 | 0.00 | 279 | |
| | | | 0.0 | 135 | 0.00 | 280 | |
| | | | 0.0 | 135 | 0.00 | 281 | |
| | | | 0.1 | 135 | 0.00 | 282 | |
| | | | 0.1 | 135 | 0.00 | 283 | |
| | | | 0.1 | 135 | 0.00 | 284 | |
| | | | 0.1 | 135 | 0.01 | 285 | |
| | | | 0.1 | 135 | 0.01 | 286 | |
| | | | 0.1 | 135 | 0.01 | 287 | |
| | | | 0.1 | 135 | 0.01 | 288 | |
| | | | 0.1 | 135 | 0.01 | 289 | |
| | | | 0.1 | 135 | 0.01 | 290 | |
| | | | 0.1 | 135 | 0.01 | 291 | |
| | | | 0.1 | 135 | 0.01 | 292 | |
| | | | 0.2 | 135 | 0.01 | 293 | |
| | | | 0.2 | 135 | 0.01 | 294 | |
| | | | 0.2 | 135 | 0.01 | 295 | |
| | | | 0.2 | 135 | 0.01 | 296 | |
| | | | 0.2 | 135 | 0.01 | 297 | |
| | | | 0.2 | 135 | 0.01 | 298 | |
| | | | 0.2 | 135 | 0.01 | 299 | |
| | | | 0.2 | 135 | 0.01 | 300 | |
| | | | 0.2 | 135 | 0.01 | 301 | |
| | | | 0.2 | 135 | 0.01 | 302 | |
| | | | 0.2 | 135 | 0.02 | 303 | |
| 11/21/2013 | **0.47** | 0.3 | 0.3 | 135 | 0.02 | 304 | |
| | | | 0.3 | 135 | 0.02 | 305 | |
| | | | 0.3 | 135 | 0.02 | 306 | |
| | | | 0.3 | 135 | 0.02 | 307 | |
| | | | 0.3 | 135 | 0.02 | 308 | |
| | | | 0.3 | 135 | 0.02 | 309 | |
| | | | 0.3 | 135 | 0.02 | 310 | |
| | | | 0.4 | 135 | 0.02 | 311 | |
| | | | 0.4 | 135 | 0.02 | 312 | |
| | | | 0.4 | 135 | 0.02 | 313 | |
| | | | 0.4 | 135 | 0.03 | 314 | |
| | | | 0.4 | 135 | 0.03 | 315 | |
| | | | 0.4 | 135 | 0.03 | 316 | |
| | | | 0.4 | 135 | 0.03 | 317 | |
| | | | 0.5 | 135 | 0.03 | 318 | |
| | | | 0.5 | 135 | 0.03 | 319 | |
| | | | 0.5 | 135 | 0.03 | 320 | |
| | | | 0.5 | 135 | 0.03 | 321 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0.5 | 135 | 0.03 | 322 | |
| | | | 0.5 | 135 | 0.03 | 323 | |
| | | | 0.5 | 135 | 0.03 | 324 | |
| | | | 0.6 | 135 | 0.04 | 325 | |
| | | | 0.6 | 135 | 0.04 | 326 | |
| | | | 0.6 | 135 | 0.04 | 327 | |
| | | | 0.6 | 135 | 0.04 | 328 | |
| | | | 0.6 | 135 | 0.04 | 329 | |
| | | | 0.6 | 135 | 0.04 | 330 | |
| 12/18/2013 | **0.64** | 0.64 | 0.64 | 135 | 0.04 | 331 | Tedlar bag Sample |
| | | | 0.6 | 135 | 0.04 | 332 | |
| | | | 0.6 | 135 | 0.04 | 333 | |
| | | | 0.6 | 135 | 0.04 | 334 | |
| | | | 0.6 | 135 | 0.04 | 335 | |
| | | | 0.6 | 135 | 0.04 | 336 | |
| | | | 0.6 | 135 | 0.04 | 337 | |
| | | | 0.5 | 135 | 0.04 | 338 | |
| | | | 0.5 | 135 | 0.03 | 339 | |
| | | | 0.5 | 135 | 0.03 | 340 | |
| | | | 0.5 | 135 | 0.03 | 341 | |
| | | | 0.5 | 135 | 0.03 | 342 | |
| | | | 0.5 | 135 | 0.03 | 343 | |
| | | | 0.5 | 135 | 0.03 | 344 | |
| | | | 0.5 | 135 | 0.03 | 345 | |
| | | | 0.4 | 135 | 0.03 | 346 | |
| | | | 0.4 | 135 | 0.03 | 347 | |
| | | | 0.4 | 135 | 0.03 | 348 | |
| | | | 0.4 | 135 | 0.03 | 349 | |
| | | | 0.4 | 135 | 0.03 | 350 | |
| | | | 0.4 | 135 | 0.02 | 351 | |
| | | | 0.4 | 135 | 0.02 | 352 | |
| | | | 0.4 | 135 | 0.02 | 353 | |
| | | | 0.3 | 135 | 0.02 | 354 | |
| | | | 0.3 | 135 | 0.02 | 355 | |
| | | | 0.3 | 135 | 0.02 | 356 | |
| | | | 0.3 | 135 | 0.02 | 357 | |
| | | | 0.3 | 135 | 0.02 | 358 | |
| 1/15/2014 | **0.51** | 0.28 | 0.28 | 135 | 0.02 | 359 | |
| | | | 0.3 | 135 | 0.02 | 360 | |
| | | | 0.3 | 135 | 0.02 | 361 | |
| | | | 0.2 | 135 | 0.02 | 362 | |
| | | | 0.2 | 135 | 0.02 | 363 | |
| | | | 0.2 | 135 | 0.01 | 364 | |
| | | | 0.2 | 135 | 0.01 | 365 | |
| | **0.38** | 0.20 | 0.20 | 135 | 0.01 | 366 | |
| 1/23/2014 | **1.00** | 0.54 | 0.54 | 101 | 0.03 | 367 | System Operational Change, closed SVE-2 and SVE-3 and ran from SVE-1 and SVE-4 to maximize extraction rate. |
| | | | 0.5 | 101 | 0.03 | 368 | |
| | | | 0.6 | 101 | 0.03 | 369 | |
| 1/26/2014 | | | 0.6 | 0 | 0.00 | 370 | System Down-Estimate |
| 2/4/2014 | **6.74** | 3.6 | 0.6 | 101 | 0.03 | 371 | High reading, system had been down upon arrival. Value considered PID error, did not include in mass totals. Restarted system. |
| 2/24/2014 | **17.90** | 9.7 | 0.6 | 101 | 0.03 | 372 | Upon inspection system had shutdown due to high water in moisture seperator. PLC indicated system shutdown shortly after 2/4/14 restart. Did not use this reading in mass calculation. |
| | | | 0.6 | 101 | 0.03 | 373 | |
| | | | 0.6 | 101 | 0.03 | 374 | |
| | | | 0.6 | 101 | 0.03 | 375 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0.6 | 101 | 0.03 | 376 | |
| | | | 0.6 | 101 | 0.03 | 377 | |
| | | | 0.6 | 101 | 0.03 | 378 | |
| | | | 0.6 | 101 | 0.03 | 379 | |
| | | | 0.6 | 101 | 0.03 | 380 | |
| | | | 0.6 | 101 | 0.03 | 381 | |
| | | | 0.6 | 101 | 0.03 | 382 | |
| | | | 0.6 | 101 | 0.03 | 383 | |
| | | | 0.6 | 101 | 0.03 | 384 | |
| | | | 0.6 | 101 | 0.03 | 385 | |
| | | | 0.6 | 101 | 0.03 | 386 | |
| | | | 0.6 | 101 | 0.03 | 387 | |
| | | | 0.7 | 101 | 0.03 | 388 | |
| 3/13/2014 | **1.22** | 0.7 | 0.7 | 101 | 0.03 | 389 | |
| | | | 0.7 | 101 | 0.03 | 390 | |
| | | | 0.7 | 101 | 0.03 | 391 | |
| | | | 0.7 | 101 | 0.04 | 392 | |
| | | | 0.7 | 101 | 0.04 | 393 | |
| | | | 0.8 | 101 | 0.04 | 394 | |
| | | | 0.8 | 101 | 0.04 | 395 | |
| | | | 0.8 | 101 | 0.04 | 396 | |
| | | | 0.8 | 101 | 0.04 | 397 | |
| | | | 0.9 | 101 | 0.04 | 398 | |
| | | | 0.9 | 101 | 0.04 | 399 | |
| | | | 0.9 | 101 | 0.04 | 400 | |
| | | | 0.9 | 101 | 0.04 | 401 | |
| | | | 0.9 | 101 | 0.05 | 402 | |
| | | | 1.0 | 101 | 0.05 | 403 | |
| | | | 1.0 | 101 | 0.05 | 404 | |
| | | | 1.0 | 101 | 0.05 | 405 | |
| | | | 1.0 | 101 | 0.05 | 406 | |
| | | | 1.0 | 101 | 0.05 | 407 | |
| | | | 1.1 | 101 | 0.05 | 408 | |
| | | | 1.1 | 101 | 0.05 | 409 | |
| | | | 1.1 | 101 | 0.05 | 410 | |
| | | | 1.1 | 101 | 0.06 | 411 | |
| | | | 1.2 | 101 | 0.06 | 412 | |
| | | | 1.2 | 101 | 0.06 | 413 | |
| | | | 1.2 | 101 | 0.06 | 414 | |
| | | | 1.2 | 101 | 0.06 | 415 | |
| 4/9/2014 | **2.30** | 1.2 | 1.2 | 109 | 0.07 | 416 | |
| | | | 1.2 | 109 | 0.06 | 417 | |
| | | | 1.2 | 109 | 0.06 | 418 | |
| | | | 1.2 | 109 | 0.06 | 419 | |
| | | | 1.1 | 109 | 0.06 | 420 | |
| | | | 1.1 | 109 | 0.06 | 421 | |
| | | | 1.1 | 109 | 0.06 | 422 | |
| | | | 1.1 | 109 | 0.06 | 423 | |
| | | | 1.1 | 109 | 0.06 | 424 | |
| | | | 1.0 | 109 | 0.05 | 425 | |
| | | | 1.0 | 109 | 0.05 | 426 | |
| | | | 1.0 | 109 | 0.05 | 427 | |
| | | | 1.0 | 109 | 0.05 | 428 | |
| | | | 0.9 | 109 | 0.05 | 429 | |
| | | | 0.9 | 109 | 0.05 | 430 | |
| | | | 0.9 | 109 | 0.05 | 431 | |
| | | | 0.9 | 109 | 0.05 | 432 | |
| | | | 0.8 | 109 | 0.04 | 433 | |
| | | | 0.8 | 109 | 0.04 | 434 | |
| | | | 0.8 | 109 | 0.04 | 435 | |
| | | | 0.8 | 109 | 0.04 | 436 | |
| 4/30/2014 | **1.32** | 0.7 | 0.7 | 109 | 0.04 | 437 | |
| | | | 0.7 | 109 | 0.04 | 438 | |
| | | | 0.7 | 109 | 0.04 | 439 | |
| | | | 0.6 | 109 | 0.03 | 440 | |
| | | | 0.6 | 109 | 0.03 | 441 | |
| | | | 0.6 | 109 | 0.03 | 442 | |
| | | | 0.6 | 109 | 0.03 | 443 | |
| | | | 0.6 | 109 | 0.03 | 444 | |
| | | | 0.5 | 109 | 0.03 | 445 | |
| | | | 0.5 | 109 | 0.03 | 446 | |
| | | | 0.5 | 109 | 0.03 | 447 | |
| | | | 0.5 | 109 | 0.02 | 448 | |
| | | | 0.4 | 109 | 0.02 | 449 | |
| | | | 0.4 | 109 | 0.02 | 450 | |
| | | | 0.4 | 109 | 0.02 | 451 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0.4 | 109 | 0.02 | 452 | |
| 5/16/2014 | **0.63** | 0.34 | 0.3 | 92 | 0.02 | 453 | |
| | | | 0.3 | 92 | 0.02 | 454 | |
| | | | 0.3 | 92 | 0.02 | 455 | |
| | | | 0.3 | 92 | 0.02 | 456 | |
| | | | 0.3 | 92 | 0.02 | 457 | |
| | | | 0.3 | 92 | 0.02 | 458 | |
| | | | 0.3 | 92 | 0.02 | 459 | |
| | | | 0.3 | 92 | 0.02 | 460 | |
| | | | 0.3 | 92 | 0.02 | 461 | |
| | | | 0.4 | 92 | 0.02 | 462 | |
| | | | 0.4 | 92 | 0.02 | 463 | |
| | | | 0.4 | 92 | 0.02 | 464 | |
| | | | 0.4 | 92 | 0.02 | 465 | |
| | | | 0.4 | 92 | 0.02 | 466 | |
| 5/30/2014 | **0.66** | 0.36 | 0.4 | 92 | 0.016 | 467 | |
| | | | 0.4 | 101 | 0.017 | 468 | |
| | | | 0.4 | 101 | 0.018 | 469 | |
| | | | 0.4 | 101 | 0.018 | 470 | |
| | | | 0.4 | 101 | 0.018 | 471 | |
| | | | 0.4 | 101 | 0.018 | 472 | |
| | | | 0.4 | 101 | 0.018 | 473 | |
| | | | 0.4 | 101 | 0.018 | 474 | |
| | | | 0.4 | 101 | 0.018 | 475 | |
| | | | 0.4 | 101 | 0.018 | 476 | |
| | | | 0.4 | 101 | 0.019 | 477 | |
| | | | 0.4 | 101 | 0.019 | 478 | |
| | | | 0.4 | 101 | 0.019 | 479 | |
| | | | 0.4 | 101 | 0.019 | 480 | |
| | | | 0.4 | 101 | 0.019 | 481 | |
| | | | 0.4 | 101 | 0.019 | 482 | |
| | | | 0.4 | 101 | 0.019 | 483 | |
| | | | 0.4 | 101 | 0.020 | 484 | |
| | | | 0.4 | 101 | 0.020 | 485 | |
| | | | 0.4 | 101 | 0.020 | 486 | |
| | | | 0.4 | 101 | 0.020 | 487 | |
| | | | 0.4 | 101 | 0.020 | 488 | |
| | | | 0.4 | 101 | 0.020 | 489 | |
| | | | 0.4 | 101 | 0.020 | 490 | |
| 6/23/2014 | **0.42** | 0.4 | 0.4 | 101 | 0.020 | 491 | Rebound Test Started, Tedlar bag sample taken at inlet. |
| | | | **Total TCE Removed (lbs)** | | **40.0** | | |

(1) The column labeled PID reading corresponds to measurments from from system operation (with PID calibrated to isobutylene)

(2)The column labeled TCE Concentration is based on converting the PID reading to actual TCE concentration by using the conversion factor of 0.54 for isobutylene to TCE.

(3) The column labeled Interpolated TCE Concentration interpolates TCE concentrations for the days of operation between PID measurements.

## South Sheetpile TCE Mass Removal Estimates and System Operation Data

| Date | PID Reading [1] (ppmv) | TCE Concentration [2] (ppmv) | Interpolated TCE Concentration [3] (ppmv) | Flow (cfm) | TCE Removed (lbs) | Days in Operation | Operational Notes |
|---|---|---|---|---|---|---|---|
| 1/8/2013 | **4.2** | 2.3 | 2.3 | 135 | 0.15 | 1 | Initial system startup. |
| 1/9/2013 | **1.3** | 0.7 | 0.7 | 135 | 0.05 | 2 | |
| | | | 0.8 | 135 | 0.05 | 3 | |
| 1/11/2013 | **1.5** | 0.8 | 0.8 | 135 | 0.05 | 4 | |
| | | | 0.8 | 135 | 0.05 | 5 | |
| | | | 0.9 | 135 | 0.06 | 6 | |
| 1/14/2013 | **1.7** | 0.9 | 0.9 | 135 | 0.06 | 7 | |
| | | | 0.7 | 135 | 0.05 | 8 | |
| | | | 0.5 | 135 | 0.04 | 9 | |
| | | | 0.4 | 135 | 0.02 | 10 | |
| 1/18/2013 | **0.4** | 0.2 | 0.2 | 120 | 0.01 | 11 | |
| | | | 0.2 | 120 | 0.01 | 12 | |
| | | | 0.3 | 120 | 0.02 | 13 | |
| | | | 0.3 | 120 | 0.02 | 14 | |
| 1/22/2013 | **0.67** | 0.4 | 0.4 | 120 | 0.02 | 15 | |
| | | | 0.4 | 120 | 0.02 | 16 | |
| | | | 0.4 | 120 | 0.02 | 17 | |
| | | | 0.4 | 120 | 0.02 | 18 | |
| | | | 0.4 | 120 | 0.02 | 19 | |
| | | | 0.4 | 120 | 0.02 | 20 | |
| | | | 0.4 | 120 | 0.02 | 21 | |
| 1/29/2013 | **0.8** | 0.4 | 0.4 | 120 | 0.03 | 22 | |
| | | | 0.4 | 120 | 0.03 | 23 | |
| | | | 0.4 | 120 | 0.03 | 24 | |
| 2/1/2013 | **0.82** | 0.4 | 0.4 | 120 | 0.03 | 25 | |
| | | | 0.4 | 120 | 0.02 | 26 | |
| | | | 0.4 | 120 | 0.02 | 27 | |
| | | | 0.3 | 120 | 0.02 | 28 | |
| 2/5/2013 | **0.57** | 0.3 | 0.3 | 120 | 0.02 | 29 | |
| | | | 0.3 | 120 | 0.02 | 30 | |
| | | | 0.3 | 120 | 0.02 | 31 | |
| | | | 0.3 | 120 | 0.02 | 32 | |
| | | | 0.3 | 120 | 0.02 | 33 | |
| | | | 0.3 | 120 | 0.02 | 34 | |
| | | | 0.3 | 120 | 0.02 | 35 | |
| 2/12/2013 | **0.49** | 0.3 | 0.3 | 120 | 0.02 | 36 | |
| | | | 0.3 | 120 | 0.01 | 37 | |
| | | | 0.2 | 120 | 0.01 | 38 | |
| | | | 0.2 | 120 | 0.01 | 39 | |
| | | | 0.2 | 120 | 0.01 | 40 | |
| | | | 0.2 | 120 | 0.01 | 41 | |
| | | | 0.2 | 120 | 0.01 | 42 | |
| | | | 0.2 | 120 | 0.01 | 43 | |
| | | | 0.2 | 120 | 0.01 | 44 | |
| 2/21/2013 | **0.33** | 0.2 | 0.2 | 120 | 0.01 | 45 | |
| | | | 0.2 | 120 | 0.01 | 46 | |
| | | | 0.3 | 120 | 0.02 | 47 | |
| | | | 0.3 | 120 | 0.02 | 48 | |
| | | | 0.4 | 120 | 0.02 | 49 | |
| | | | 0.4 | 120 | 0.02 | 50 | |
| | | | 0.5 | 120 | 0.03 | 51 | |
| | | | 0.5 | 120 | 0.03 | 52 | |
| | | | 0.5 | 120 | 0.03 | 53 | |
| | | | 0.6 | 120 | 0.03 | 54 | |
| | | | 0.6 | 120 | 0.04 | 55 | |
| | | | 0.7 | 120 | 0.04 | 56 | |
| | | | 0.7 | 120 | 0.04 | 57 | |
| 3/6/2013 | **1.44** | 0.8 | 0.8 | 120 | 0.04 | 58 | |
| | | | 0.7 | 120 | 0.04 | 59 | |
| | | | 0.7 | 120 | 0.04 | 60 | |
| | | | 0.7 | 120 | 0.04 | 61 | |
| | | | 0.7 | 120 | 0.04 | 62 | |
| | | | 0.6 | 120 | 0.04 | 63 | |
| | | | 0.6 | 120 | 0.03 | 64 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 0.6 | 120 | 0.03 | 65 | | |
| | | | 0.5 | 120 | 0.03 | 66 | | |
| | | | 0.5 | 120 | 0.03 | 67 | | |
| | | | 0.5 | 120 | 0.03 | 68 | | |
| | | | 0.4 | 120 | 0.03 | 69 | | |
| | | | 0.4 | 120 | 0.02 | 70 | | |
| | | | 0.4 | 120 | 0.02 | 71 | | |
| | | | 0.3 | 120 | 0.02 | 72 | | |
| | | | 0.3 | 120 | 0.02 | 73 | | |
| | | | 0.3 | 120 | 0.02 | 74 | | |
| | | | 0.3 | 120 | 0.01 | 75 | | |
| | | | 0.2 | 120 | 0.01 | 76 | | |
| 3/25/2013 | **0.36** | 0.2 | 0.2 | 120 | 0.01 | 77 | | |
| | | | 0.2 | 120 | 0.01 | 78 | | |
| | | | 0.2 | 120 | 0.01 | 79 | | |
| | | | 0.1 | 120 | 0.01 | 80 | | |
| | | | 0.1 | 120 | 0.01 | 81 | | |
| 4/2/2013 | **0.18** | 0.1 | 0.1 | 120 | 0.01 | 82 | | |
| | | | 0.1 | 120 | 0.01 | 83 | | |
| | | | 0.1 | 120 | 0.01 | 84 | | |
| | | | 0.1 | 120 | 0.01 | 85 | | |
| | | | 0.1 | 120 | 0.01 | 86 | | |
| | | | 0.1 | 120 | 0.01 | 87 | | |
| | | | 0.1 | 120 | 0.00 | 88 | | |
| | | | 0.1 | 120 | 0.00 | 89 | | |
| | | | 0.1 | 120 | 0.00 | 90 | | |
| | | | 0.1 | 120 | 0.00 | 91 | | |
| | | | 0.1 | 120 | 0.00 | 92 | | |
| | | | 0.1 | 120 | 0.00 | 93 | | |
| | | | 0.1 | 120 | 0.00 | 94 | | |
| 4/15/2013 | **0.13** | 0.1 | 0.1 | 120 | 0.00 | 95 | | |
| | | | 0.1 | 120 | 0.00 | 96 | | |
| | | | 0.1 | 120 | 0.00 | 97 | | |
| | | | 0.1 | 120 | 0.00 | 98 | | |
| | | | 0.1 | 120 | 0.00 | 99 | | |
| | | | 0.1 | 120 | 0.00 | 100 | Construction Report | |
| | | | 0.1 | 120 | 0.00 | 101 | | |
| | | | 0.1 | 120 | 0.01 | 102 | | |
| | | | 0.1 | 120 | 0.01 | 103 | | |
| | | | 0.1 | 120 | 0.01 | 104 | | |
| 4/25/2013 | **0.00** | 0.0 | 0.1 | 120 | 0.01 | 105 | Reading not consistent not used in mass removal estimate. | |
| | | | 0.1 | 120 | 0.01 | 106 | | |
| | | | 0.1 | 120 | 0.01 | 107 | | |
| | | | 0.1 | 120 | 0.01 | 108 | | |
| | | | 0.1 | 120 | 0.01 | 109 | | |
| | | | 0.1 | 120 | 0.01 | 110 | | |
| | | | 0.1 | 120 | 0.01 | 111 | | |
| | | | 0.1 | 120 | 0.01 | 112 | | |
| | | | 0.1 | 120 | 0.01 | 113 | | |
| | | | 0.1 | 120 | 0.01 | 114 | | |
| | | | 0.1 | 120 | 0.01 | 115 | | |
| | | | 0.1 | 120 | 0.01 | 116 | | |
| | | | 0.1 | 120 | 0.01 | 117 | | |
| | | | 0.1 | 120 | 0.01 | 118 | | |
| | | | 0.1 | 120 | 0.01 | 119 | | |
| 5/10/2013 | **6.04** | | 0.1 | 120 | 0.01 | 120 | Reading not consistent not used in mass removal estimate. | |
| | | | 0.1 | 120 | 0.01 | 121 | | |
| | | | 0.1 | 120 | 0.01 | 122 | | |
| | | | 0.1 | 120 | 0.01 | 123 | | |
| | | | 0.1 | 120 | 0.01 | 124 | | |
| | | | 0.1 | 120 | 0.01 | 125 | | |
| | | | 0.1 | 120 | 0.01 | 126 | | |
| 5/17/2013 | **5.17** | | 0.1 | 120 | 0.01 | 127 | Reading not consistent not used in mass removal estimate. | |
| | | | 0.2 | 120 | 0.01 | 128 | | |
| | | | 0.2 | 120 | 0.01 | 129 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 0.2 | 120 | 0.01 | 130 | |
| | | | | 0.2 | 120 | 0.01 | 131 | |
| | | | | 0.2 | 120 | 0.01 | 132 | |
| | | | | 0.2 | 120 | 0.01 | 133 | |
| | | | | 0.2 | 120 | 0.01 | 134 | |
| | | | | 0.2 | 120 | 0.01 | 135 | |
| | | | | 0.2 | 120 | 0.01 | 136 | |
| | | | | 0.2 | 120 | 0.01 | 137 | |
| | | | | 0.2 | 120 | 0.01 | 138 | |
| | | | | 0.2 | 120 | 0.01 | 139 | |
| | | | | 0.2 | 120 | 0.01 | 140 | |
| | | | | 0.2 | 120 | 0.01 | 141 | |
| | | | | 0.2 | 120 | 0.01 | 142 | |
| | | | | 0.2 | 120 | 0.01 | 143 | |
| | | | | 0.2 | 120 | 0.01 | 144 | |
| | | | | 0.2 | 120 | 0.01 | 145 | |
| | | | | 0.2 | 120 | 0.01 | 146 | |
| | | | | 0.2 | 120 | 0.01 | 147 | |
| | | | | 0.2 | 120 | 0.01 | 148 | |
| | | | | 0.2 | 120 | 0.01 | 149 | |
| | | | | 0.2 | 120 | 0.01 | 150 | |
| | | | | 0.2 | 120 | 0.01 | 151 | |
| | | | | 0.2 | 120 | 0.01 | 152 | |
| | | | | 0.2 | 120 | 0.01 | 153 | |
| | | | | 0.2 | 120 | 0.01 | 154 | |
| | | | | 0.2 | 120 | 0.01 | 155 | |
| | | | | 0.2 | 120 | 0.01 | 156 | |
| | | | | 0.2 | 120 | 0.01 | 157 | |
| | | | | 0.2 | 120 | 0.01 | 158 | |
| | | | | 0.2 | 120 | 0.01 | 159 | |
| | | | | 0.2 | 120 | 0.01 | 160 | |
| | | | | 0.2 | 120 | 0.01 | 161 | |
| | | | | 0.2 | 120 | 0.01 | 162 | Assume belts broke today. |
| | | | | 0.2 | 0 | 0.00 | 163 | |
| | | | | 0.2 | 0 | 0.00 | 164 | |
| | 6/24/2013 | **2.06** | 1.1 | 0.2 | 120 | 0.01 | 165 | Changed oil and belts, belts were broken on arrival. Two days prior system was running, assume belts broke two days prior |
| | | | | 0.2 | 120 | 0.01 | 166 | |
| | | | | 0.2 | 120 | 0.01 | 167 | |
| | | | | 0.2 | 120 | 0.01 | 168 | |
| | | | | 0.2 | 120 | 0.01 | 169 | |
| | | | | 0.3 | 120 | 0.01 | 170 | |
| | | | | 0.3 | 120 | 0.01 | 171 | |
| | | | | 0.3 | 120 | 0.01 | 172 | |
| | | | | 0.3 | 120 | 0.01 | 173 | |
| | | | | 0.3 | 120 | 0.02 | 174 | |
| | | | | 0.3 | 120 | 0.02 | 175 | |
| | | | | 0.3 | 120 | 0.02 | 176 | |
| | | | | 0.3 | 120 | 0.02 | 177 | |
| | | | | 0.3 | 120 | 0.02 | 178 | |
| | | | | 0.3 | 120 | 0.02 | 179 | |
| | | | | 0.3 | 120 | 0.02 | 180 | |
| | | | | 0.3 | 120 | 0.02 | 181 | |
| | | | | 0.3 | 120 | 0.02 | 182 | |
| | | | | 0.3 | 120 | 0.02 | 183 | |
| | | | | 0.3 | 120 | 0.02 | 184 | |
| | | | | 0.3 | 120 | 0.02 | 185 | |
| | | | | 0.3 | 120 | 0.02 | 186 | |
| | | | | 0.3 | 120 | 0.02 | 187 | |
| | | | | 0.3 | 120 | 0.02 | 188 | |
| | | | | 0.3 | 120 | 0.02 | 189 | |
| | 7/19/2013 | **0.55** | 0.3 | 0.3 | 120 | 0.02 | 190 | |
| | | | | 0.3 | 120 | 0.02 | 191 | |
| | | | | 0.3 | 120 | 0.02 | 192 | |
| | | | | 0.3 | 120 | 0.02 | 193 | |
| | | | | 0.3 | 120 | 0.02 | 194 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0.3 | 120 | 0.02 | 195 | |
| | | | 0.3 | 120 | 0.02 | 196 | |
| | | | 0.4 | 120 | 0.02 | 197 | |
| | | | 0.4 | 120 | 0.02 | 198 | |
| | | | 0.4 | 120 | 0.02 | 199 | |
| | | | 0.4 | 120 | 0.02 | 200 | |
| | | | 0.4 | 120 | 0.02 | 201 | |
| | | | 0.4 | 120 | 0.02 | 202 | |
| | | | 0.4 | 120 | 0.02 | 203 | |
| | | | 0.4 | 120 | 0.02 | 204 | |
| | | | 0.4 | 120 | 0.02 | 205 | |
| | | | 0.4 | 120 | 0.03 | 206 | |
| | | | 0.4 | 120 | 0.03 | 207 | |
| | | | 0.5 | 120 | 0.03 | 208 | |
| | | | 0.5 | 120 | 0.03 | 209 | |
| | | | 0.5 | 120 | 0.03 | 210 | |
| | | | 0.5 | 120 | 0.03 | 211 | |
| | | | 0.5 | 120 | 0.03 | 212 | |
| | | | 0.5 | 120 | 0.03 | 213 | |
| | | | 0.5 | 120 | 0.03 | 214 | |
| | | | 0.5 | 120 | 0.03 | 215 | |
| | | | 0.5 | 120 | 0.03 | 216 | |
| | | | 0.5 | 120 | 0.03 | 217 | |
| | | | 0.5 | 120 | 0.03 | 218 | |
| | | | 0.5 | 120 | 0.03 | 219 | |
| | | | 0.6 | 120 | 0.03 | 220 | |
| | | | 0.6 | 120 | 0.03 | 221 | |
| | | | 0.6 | 120 | 0.03 | 222 | |
| | | | 0.6 | 120 | 0.03 | 223 | |
| 8/22/2013 | **1.09** | 0.6 | 0.6 | 120 | 0.03 | 224 | |
| | | | 0.6 | 120 | 0.03 | 225 | |
| | | | 0.6 | 120 | 0.03 | 226 | |
| | | | 0.5 | 120 | 0.03 | 227 | |
| | | | 0.5 | 120 | 0.03 | 228 | |
| | | | 0.5 | 120 | 0.03 | 229 | |
| | | | 0.5 | 120 | 0.03 | 230 | |
| | | | 0.5 | 120 | 0.03 | 231 | |
| | | | 0.5 | 120 | 0.03 | 232 | |
| | | | 0.5 | 120 | 0.03 | 233 | |
| | | | 0.5 | 120 | 0.03 | 234 | |
| | | | 0.4 | 120 | 0.03 | 235 | |
| | | | 0.4 | 120 | 0.02 | 236 | |
| | | | 0.4 | 120 | 0.02 | 237 | |
| | | | 0.4 | 120 | 0.02 | 238 | |
| | | | 0.4 | 120 | 0.02 | 239 | |
| | | | 0.4 | 120 | 0.02 | 240 | |
| | | | 0.4 | 120 | 0.02 | 241 | |
| | | | 0.4 | 120 | 0.02 | 242 | |
| | | | 0.3 | 120 | 0.02 | 243 | |
| | | | 0.3 | 120 | 0.02 | 244 | |
| | | | 0.3 | 120 | 0.02 | 245 | |
| | | | 0.3 | 120 | 0.02 | 246 | |
| | | | 0.3 | 120 | 0.02 | 247 | |
| | | | 0.3 | 120 | 0.02 | 248 | |
| | | | 0.3 | 120 | 0.01 | 249 | |
| | | | 0.2 | 120 | 0.01 | 250 | |
| | | | 0.2 | 120 | 0.01 | 251 | |
| | | | 0.2 | 120 | 0.01 | 252 | |
| | | | 0.2 | 120 | 0.01 | 253 | |
| | | | 0.2 | 120 | 0.01 | 254 | |
| | | | 0.2 | 120 | 0.01 | 255 | |
| | | | 0.2 | 120 | 0.01 | 256 | |
| | | | 0.2 | 120 | 0.01 | 257 | |
| | | | 0.1 | 120 | 0.01 | 258 | |
| | | | 0.1 | 120 | 0.01 | 259 | |
| | | | 0.1 | 120 | 0.01 | 260 | |
| | | | 0.1 | 120 | 0.01 | 261 | |
| | | | 0.09 | 120 | 0.01 | 262 | |
| | | | 0.07 | 120 | 0.004 | 263 | |
| 10/1/2013 | **0.11** | 0.06 | 0.06 | 120 | 0.003 | 264 | |
| | | | 0.06 | 120 | 0.004 | 265 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 0.06 | 120 | 0.004 | 266 | | |
| | | | 0.06 | 120 | 0.004 | 267 | | |
| | | | 0.06 | 120 | 0.004 | 268 | | |
| | | | 0.06 | 120 | 0.004 | 269 | | |
| | | | 0.06 | 120 | 0.004 | 270 | | |
| | | | 0.06 | 120 | 0.004 | 271 | | |
| | | | 0.06 | 120 | 0.004 | 272 | | |
| | | | 0.06 | 120 | 0.004 | 273 | | |
| | | | 0.06 | 120 | 0.004 | 274 | | |
| | | | 0.06 | 120 | 0.004 | 275 | | |
| | | | 0.06 | 120 | 0.004 | 276 | | |
| | | | 0.06 | 120 | 0.004 | 277 | | |
| | | | 0.06 | 120 | 0.004 | 278 | | |
| | | | 0.06 | 120 | 0.004 | 279 | | |
| | | | 0.06 | 120 | 0.004 | 280 | | |
| | | | 0.06 | 120 | 0.004 | 281 | | |
| | | | 0.06 | 120 | 0.004 | 282 | | |
| | | | 0.06 | 120 | 0.004 | 283 | | |
| | | | 0.06 | 120 | 0.004 | 284 | | |
| | | | 0.06 | 120 | 0.004 | 285 | | |
| 10/23/2013 | **0.07** | 0.07 | 0.07 | 120 | 0.004 | 286 | Tedlar Bag Sample | |
| 10/24/2013 | **0.44** | 0.23 | 0.23 | 120 | 0.014 | 287 | | |
| | | | 0.06 | 120 | 0.004 | 288 | | |
| | | | 0.06 | 120 | 0.004 | 289 | | |
| | | | 0.06 | 120 | 0.004 | 290 | | |
| | | | 0.06 | 120 | 0.004 | 291 | | |
| | | | 0.06 | 120 | 0.004 | 292 | | |
| | | | 0.06 | 120 | 0.004 | 293 | | |
| | | | 0.06 | 120 | 0.004 | 294 | | |
| | | | 0.06 | 120 | 0.004 | 295 | | |
| | | | 0.06 | 120 | 0.004 | 296 | | |
| | | | 0.06 | 120 | 0.004 | 297 | | |
| | | | 0.06 | 120 | 0.004 | 298 | | |
| | | | 0.06 | 120 | 0.004 | 299 | | |
| | | | 0.06 | 120 | 0.003 | 300 | | |
| | | | 0.06 | 120 | 0.003 | 301 | | |
| | | | 0.06 | 120 | 0.003 | 302 | | |
| | | | 0.06 | 120 | 0.003 | 303 | | |
| | | | 0.06 | 120 | 0.003 | 304 | | |
| | | | 0.06 | 120 | 0.003 | 305 | | |
| | | | 0.06 | 120 | 0.003 | 306 | | |
| | | | 0.06 | 120 | 0.003 | 307 | | |
| | | | 0.06 | 120 | 0.003 | 308 | | |
| | | | 0.06 | 120 | 0.003 | 309 | | |
| | | | 0.06 | 120 | 0.003 | 310 | | |
| | | | 0.06 | 120 | 0.003 | 311 | | |
| | | | 0.06 | 120 | 0.003 | 312 | | |
| | | | 0.06 | 120 | 0.003 | 313 | | |
| | | | 0.06 | 120 | 0.003 | 314 | | |
| 11/21/2013 | **0.10** | 0.055 | 0.05 | 120 | 0.003 | 315 | | |
| | | | 0.05 | 120 | 0.003 | 316 | | |
| | | | 0.05 | 120 | 0.003 | 317 | | |
| | | | 0.05 | 120 | 0.003 | 318 | | |
| | | | 0.05 | 120 | 0.003 | 319 | | |
| | | | 0.05 | 120 | 0.003 | 320 | | |
| | | | 0.05 | 120 | 0.003 | 321 | | |
| | | | 0.05 | 120 | 0.003 | 322 | | |
| | | | 0.05 | 120 | 0.003 | 323 | | |
| | | | 0.05 | 120 | 0.003 | 324 | | |
| | | | 0.05 | 120 | 0.003 | 325 | | |
| | | | 0.05 | 120 | 0.003 | 326 | | |
| | | | 0.05 | 120 | 0.003 | 327 | | |
| | | | 0.05 | 120 | 0.003 | 328 | | |
| | | | 0.05 | 120 | 0.003 | 329 | | |
| | | | 0.05 | 120 | 0.003 | 330 | | |
| | | | 0.05 | 120 | 0.003 | 331 | | |
| | | | 0.05 | 120 | 0.003 | 332 | | |
| | | | 0.05 | 120 | 0.003 | 333 | | |
| | | | 0.05 | 120 | 0.003 | 334 | | |
| | | | 0.05 | 120 | 0.003 | 335 | | |
| | | | 0.05 | 120 | 0.003 | 336 | | |

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|---|---|---|---|---|---|---|---|---|
| | | | 0.05 | 120 | 0.003 | 337 | | |
| | | | 0.05 | 120 | 0.003 | 338 | | |
| | | | 0.05 | 120 | 0.003 | 339 | | |
| | | | 0.05 | 120 | 0.003 | 340 | | |
| | | | 0.05 | 120 | 0.003 | 341 | | |
| 12/18/2013 | **0.05** | 0.047 | 0.047 | 120 | 0.003 | 342 | Tedlar Bag Sample | |
| | | | 0.05 | 120 | 0.003 | 343 | | |
| | | | 0.05 | 120 | 0.003 | 344 | | |
| | | | 0.05 | 120 | 0.003 | 345 | | |
| | | | 0.05 | 120 | 0.003 | 346 | | |
| | | | 0.05 | 120 | 0.003 | 347 | | |
| | | | 0.05 | 120 | 0.003 | 348 | | |
| | | | 0.05 | 120 | 0.003 | 349 | | |
| | | | 0.05 | 120 | 0.003 | 350 | | |
| | | | 0.05 | 120 | 0.003 | 351 | | |
| | | | 0.05 | 120 | 0.003 | 352 | | |
| | | | 0.05 | 120 | 0.003 | 353 | | |
| | | | 0.05 | 120 | 0.003 | 354 | | |
| | | | 0.05 | 120 | 0.003 | 355 | | |
| | | | 0.05 | 120 | 0.003 | 356 | | |
| | | | 0.05 | 120 | 0.003 | 357 | | |
| | | | 0.05 | 120 | 0.003 | 358 | | |
| | | | 0.05 | 120 | 0.003 | 359 | | |
| | | | 0.05 | 120 | 0.003 | 360 | | |
| | | | 0.05 | 120 | 0.003 | 361 | | |
| | | | 0.05 | 120 | 0.003 | 362 | | |
| | | | 0.05 | 120 | 0.003 | 363 | | |
| | | | 0.05 | 120 | 0.003 | 364 | | |
| | | | 0.05 | 120 | 0.003 | 365 | | |
| | | | 0.05 | 120 | 0.003 | 366 | | |
| | | | 0.05 | 120 | 0.003 | 367 | | |
| | | | 0.05 | 120 | 0.003 | 368 | | |
| | | | 0.05 | 120 | 0.003 | 369 | | |
| 1/15/2014 | **0.10** | 0.054 | 0.05 | 120 | 0.003 | 370 | | |
| | | | 0.05 | 120 | 0.003 | 371 | | |
| | | | 0.05 | 120 | 0.003 | 372 | | |
| | | | 0.05 | 120 | 0.003 | 373 | | |
| | | | 0.05 | 120 | 0.003 | 374 | | |
| | | | 0.05 | 120 | 0.003 | 375 | | |
| | | | 0.05 | 120 | 0.003 | 376 | | |
| | **0.09** | 0.050 | 0.05 | 120 | 0.003 | 377 | | |
| 1/23/2014 | **0.17** | 0.089 | 0.09 | 80 | 0.003 | 378 | System Operational Change, closed SVE-7 and ran solely from SVE-6 to maximize extraction rate. | |
| | | | 0.09 | 80 | 0.003 | 379 | | |
| | | | 0.09 | 80 | 0.003 | 380 | | |
| | | | 0.09 | 80 | 0.003 | 381 | | |
| | | | 0.09 | 80 | 0.003 | 382 | | |
| | | | 0.09 | 80 | 0.003 | 383 | | |
| | | | 0.08 | 80 | 0.003 | 384 | | |
| | | | 0.08 | 80 | 0.003 | 385 | | |
| | | | 0.08 | 80 | 0.003 | 386 | | |
| | | | 0.08 | 80 | 0.003 | 387 | | |
| | | | 0.08 | 80 | 0.003 | 388 | | |
| | | | 0.08 | 80 | 0.003 | 389 | | |
| 2/4/2014 | **0.15** | 0.081 | 0.08 | 80 | 0.003 | 390 | | |
| | | | 0.08 | 80 | 0.003 | 391 | | |
| | | | 0.07 | 80 | 0.003 | 392 | | |
| | | | 0.07 | 80 | 0.003 | 393 | | |
| | | | 0.07 | 80 | 0.003 | 394 | | |
| | | | 0.07 | 80 | 0.003 | 395 | | |
| | | | 0.06 | 80 | 0.002 | 396 | | |
| | | | 0.06 | 80 | 0.002 | 397 | | |
| | | | 0.06 | 80 | 0.002 | 398 | | |
| | | | 0.05 | 80 | 0.002 | 399 | | |
| | | | 0.05 | 80 | 0.002 | 400 | | |
| | | | 0.05 | 80 | 0.002 | 401 | | |
| | | | 0.05 | 80 | 0.002 | 402 | | |
| | | | 0.04 | 80 | 0.002 | 403 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0.04 | 80 | 0.002 | 404 | |
| | | | 0.04 | 80 | 0.001 | 405 | |
| | | | 0.03 | 80 | 0.001 | 406 | |
| | | | 0.03 | 80 | 0.001 | 407 | |
| | | | 0.03 | 80 | 0.001 | 408 | |
| | | | 0.02 | 80 | 0.001 | 409 | |
| 2/24/2014 | **0.04** | 0.022 | 0.02 | 80 | 0.001 | 410 | |
| | | | 0.02 | 80 | 0.001 | 411 | |
| | | | 0.03 | 80 | 0.001 | 412 | |
| | | | 0.03 | 80 | 0.001 | 413 | |
| | | | 0.03 | 80 | 0.001 | 414 | |
| | | | 0.03 | 80 | 0.001 | 415 | |
| | | | 0.03 | 80 | 0.001 | 416 | |
| | | | 0.03 | 80 | 0.001 | 417 | |
| | | | 0.04 | 80 | 0.001 | 418 | |
| | | | 0.04 | 80 | 0.001 | 419 | |
| | | | 0.04 | 80 | 0.002 | 420 | |
| | | | 0.04 | 80 | 0.002 | 421 | |
| | | | 0.04 | 80 | 0.002 | 422 | |
| | | | 0.05 | 80 | 0.002 | 423 | |
| | | | 0.05 | 80 | 0.002 | 424 | |
| | | | 0.05 | 80 | 0.002 | 425 | |
| | | | 0.05 | 80 | 0.002 | 426 | |
| 3/13/2014 | **0.10** | 0.053 | 0.05 | 72 | 0.002 | 427 | |
| | | | 0.06 | 75 | 0.002 | 428 | |
| | | | 0.06 | 75 | 0.002 | 429 | |
| | | | 0.07 | 75 | 0.002 | 430 | |
| | | | 0.07 | 75 | 0.003 | 431 | |
| | | | 0.08 | 75 | 0.003 | 432 | |
| | | | 0.08 | 75 | 0.003 | 433 | |
| | | | 0.09 | 75 | 0.003 | 434 | |
| | | | 0.09 | 75 | 0.003 | 435 | |
| | | | 0.10 | 75 | 0.004 | 436 | |
| | | | 0.10 | 75 | 0.004 | 437 | |
| | | | 0.11 | 75 | 0.004 | 438 | |
| | | | 0.11 | 75 | 0.004 | 439 | |
| | | | 0.12 | 75 | 0.004 | 440 | |
| | | | 0.12 | 75 | 0.004 | 441 | |
| | | | 0.13 | 75 | 0.005 | 442 | |
| | | | 0.13 | 75 | 0.005 | 443 | |
| | | | 0.14 | 75 | 0.005 | 444 | |
| | | | 0.14 | 75 | 0.005 | 445 | |
| | | | 0.15 | 75 | 0.005 | 446 | |
| | | | 0.15 | 75 | 0.005 | 447 | |
| | | | 0.16 | 75 | 0.006 | 448 | |
| | | | 0.16 | 75 | 0.006 | 449 | |
| | | | 0.17 | 75 | 0.006 | 450 | |
| | | | 0.17 | 75 | 0.006 | 451 | |
| | | | 0.18 | 75 | 0.006 | 452 | |
| | | | 0.18 | 75 | 0.007 | 453 | |
| 4/9/2014 | **0.37** | 0.186 | 0.19 | 75 | 0.007 | 454 | |
| | | | 0.18 | 75 | 0.007 | 455 | |
| | | | 0.18 | 75 | 0.006 | 456 | |
| | | | 0.17 | 75 | 0.006 | 457 | |
| | | | 0.17 | 75 | 0.006 | 458 | |
| | | | 0.17 | 75 | 0.006 | 459 | |
| | | | 0.16 | 75 | 0.006 | 460 | |
| | | | 0.16 | 75 | 0.006 | 461 | |
| | | | 0.15 | 75 | 0.006 | 462 | |
| | | | 0.15 | 75 | 0.005 | 463 | |
| | | | 0.14 | 75 | 0.005 | 464 | |
| | | | 0.14 | 75 | 0.005 | 465 | |
| | | | 0.14 | 75 | 0.005 | 466 | |
| | | | 0.13 | 75 | 0.005 | 467 | |
| | | | 0.13 | 75 | 0.005 | 468 | |
| | | | 0.12 | 75 | 0.004 | 469 | |
| | | | 0.12 | 75 | 0.004 | 470 | |
| | | | 0.12 | 75 | 0.004 | 471 | |
| | | | 0.11 | 75 | 0.004 | 472 | |
| | | | 0.11 | 75 | 0.004 | 473 | |
| | | | 0.10 | 75 | 0.004 | 474 | |

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|---|---|---|---|---|---|---|---|
| 4/30/2014 | **0.18** | 0.099 | 0.10 | 75 | 0.004 | 475 | |
| | | | 0.10 | 75 | 0.004 | 476 | |
| | | | 0.10 | 75 | 0.004 | 477 | |
| | | | 0.10 | 75 | 0.004 | 478 | |
| | | | 0.10 | 75 | 0.004 | 479 | |
| | | | 0.10 | 75 | 0.004 | 480 | |
| | | | 0.10 | 75 | 0.004 | 481 | |
| | | | 0.10 | 75 | 0.004 | 482 | |
| | | | 0.10 | 75 | 0.004 | 483 | |
| | | | 0.10 | 75 | 0.004 | 484 | |
| | | | 0.10 | 75 | 0.004 | 485 | |
| | | | 0.10 | 75 | 0.004 | 486 | |
| | | | 0.10 | 75 | 0.004 | 487 | |
| | | | 0.10 | 75 | 0.004 | 488 | |
| | | | 0.10 | 75 | 0.003 | 489 | |
| | | | 0.10 | 75 | 0.003 | 490 | |
| | | | 0.10 | 75 | 0.003 | 491 | |
| | | | 0.10 | 75 | 0.003 | 492 | |
| | | | 0.10 | 75 | 0.003 | 493 | |
| | | | 0.10 | 75 | 0.003 | 494 | |
| | | | 0.10 | 75 | 0.003 | 495 | |
| | | | 0.10 | 75 | 0.003 | 496 | |
| | | | 0.10 | 75 | 0.003 | 497 | |
| | | | 0.10 | 75 | 0.003 | 498 | |
| | | | 0.10 | 75 | 0.003 | 499 | |
| | | | 0.10 | 75 | 0.003 | 500 | |
| | | | 0.10 | 75 | 0.003 | 501 | |
| | | | 0.09 | 75 | 0.003 | 502 | |
| | | | 0.09 | 75 | 0.003 | 503 | |
| | | | 0.09 | 75 | 0.003 | 504 | |
| 5/30/2014 | **0.18** | 0.095 | 0.09 | 72 | 0.003 | 505 | |
| | | | 0.09 | 76 | 0.003 | 506 | |
| | | | 0.09 | 76 | 0.003 | 507 | |
| | | | 0.09 | 76 | 0.003 | 508 | |
| | | | 0.09 | 76 | 0.003 | 509 | |
| | | | 0.09 | 76 | 0.003 | 510 | |
| | | | 0.09 | 76 | 0.003 | 511 | |
| | | | 0.09 | 76 | 0.003 | 512 | |
| | | | 0.09 | 76 | 0.003 | 513 | |
| | | | 0.08 | 76 | 0.003 | 514 | |
| | | | 0.08 | 76 | 0.003 | 515 | |
| | | | 0.08 | 76 | 0.003 | 516 | |
| | | | 0.08 | 76 | 0.003 | 517 | |
| | | | 0.08 | 76 | 0.003 | 518 | |
| | | | 0.08 | 76 | 0.003 | 519 | |
| | | | 0.08 | 76 | 0.003 | 520 | |
| | | | 0.08 | 76 | 0.003 | 521 | |
| | | | 0.08 | 76 | 0.003 | 522 | |
| | | | 0.07 | 76 | 0.003 | 523 | |
| | | | 0.07 | 76 | 0.003 | 524 | |
| | | | 0.07 | 76 | 0.003 | 525 | |
| | | | 0.07 | 76 | 0.003 | 526 | |
| | | | 0.07 | 76 | 0.003 | 527 | |
| | | | 0.07 | 76 | 0.003 | 528 | |
| 6/23/2014 | **0.07** | 0.068 | 0.07 | 76 | 0.002 | 529 | Rebound Test Started, Tedlar bag sample taken at inlet. |
| | | | **Total TCE Removed (lbs)** | | **5.7** | | |

(1) The column labeled PID reading corresponds to measurments from from system operation (with PID calibrated to isobutylene)

(2)The column labeled TCE Concentration is based on converting the PID reading to actual TCE concentration by using the conversion factor of 0.54 for isobutylene to TCE.

(3) The column labeled Interpolated TCE Concentration interpolates TCE concentrations for the days of operation between PID measurements.

Performance Monitoring Data from Well PL2-212A

| Sample Date | TCE (ug/L) | cis-DCE (ug/L) | trans-DCE (ug/L) | VC (ug/L) | Total CVOCs (ug/L) |
|---|---|---|---|---|---|
| 3/17/2010 | 62,000 | 22,000 | 610 | 7,700 | 92,310 |
| 9/20/2012* | 2,000 | 1,800 | 36 | 160 | 3,996 |
| 10/23/2012 | 9,700 | 7,200 | 210 | 1,500 | 18,610 |
| 11/29/2012 | 6,100 | 10,000 | 350 | 2,000 | 18,450 |
| 2/26/2013 | 2,100 | 7,300 | 110 | 1,400 | 10,910 |
| 5/21/2013 | 2,500 | 4,600 | 100 | 1,800 | 9,000 |
| 8/27/2013 | 1,600 | 4,900 | 78 | 1,600 | 8,178 |
| 1/14/2014 | <2.0 | 420 | 6.6 | 550 | 977 |
| 4/29/2014 | 0.3 | 63 | 0.3 | 90 | 154 |

* Indicates first sampling event after the start of substrate injections for ERD

| Sample Date | Ethane (ug/L) | Ethene (ug/L) | Methane (ug/L) | TOC (mg/L) |
|---|---|---|---|---|
| 9/20/2012* | 40 | 38 | 110 | 19 |
| 10/23/2012 | 1,100 | 440 | 4,800 | 23.6 |
| 11/29/2012 | 830 | 810 | 3,700 | 27.1 |
| 2/26/2013 | 110 J | 96 J | 230** J | 25.0 |
| 5/21/2013 | 1,400 | 350 | 10,000 | 22.2 |
| 8/27/2013 | 1,000 | 210 | 7,200 | NS |
| 1/14/2014 | 700 | 220 | 22,000 | NS |
| 4/29/2014 | 270 | 27 | 14,000 | NS |

* Indicates first sampling event after the start of substrate injections for ERD

** Methane analysis did not produce consistent numbers in multiple trials by lab

Abbreviations:

CVOC Chlorinated volatile organic compound

DCE Dichloroethene

PCE Tetrachloroethene

TCE Trichloroethene

TOC Total Organic Carbon

VC Vinyl chloride

Qualifiers:

U Non-detect

J Estimated

Performance Monitoring Data from Well PL2-218A

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2/9/2010 | <10 | U | 1,000 | | 120 | | 480 | | 1,600 | |
| 3/18/2010 | 1.6 | | 930 | | 110 | | 460 | | 1,502 | |
| 9/20/2012* | <5.0 | U | 2,300 | | 220 | | 550 | | 3,070 | |
| 10/23/2012 | <1.0 | U | 570 | | 93 | | 240 | | 903 | |
| 11/29/2012 | 6.3 | | 2,400 | | 180 | | 640 | | 3,220 | |
| 2/27/2013 | <10 | U | 430 | | 130 | | 2,000 | | 2,560 | |
| 5/21/2013 | <0.2 | U | 37 | | 30 | | 430 | | 497 | |
| 8/27/2013 | <10 | U | 4,300 | | 230 | | 2,200 | | 6,730 | |
| 1/14/2014 | 59 | | 3,700 | | 260 | | 2,700 | | 6,719 | |
| 4/29/2014 | 1 | | 20 | | 6.8 | | 62 | | 89 | |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | 58 | | 18 | | 4,000 | | 10.7 | |
| 10/23/2012 | 44 | | 6.2 | | 5,400 | | 13.3 | |
| 11/29/2012 | 47 | | 22 | | 8,800 | | 10 | |
| 2/27/2013 | 220 | | 180 | | 9,800 | | 8.3 | |
| 5/21/2013 | 120 | | 38 | | 12,000 | | 8.2 | |
| 8/27/2013 | 86 | | 120 | | 20,000 | | NS | |
| 1/14/2014 | 190 | | 160 | | 16,000 | | NS | |
| 4/29/2014 | 90 | | 10 | | 15,000 | | NS | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

| | |
|---|---|
| CVOC | Chlorinated volatile organic compound |
| DCE | Dichloroethene |
| PCE | Tetrachloroethene |
| TCE | Trichloroethene |
| TOC | Total Organic Carbon |
| VC | Vinyl chloride |

Qualifiers:

| | |
|---|---|
| U | Non-detect |
| J | Estimated |

Performance Monitoring Data from Well PL2-218B

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2/9/2010 | <1.0 | U | 200 | | 0.5 | | 1.3 | | 202 | |
| 3/18/2010 | 1.2 | | 9,800 | | 15 | | 3.5 | | 9,820 | |
| 9/20/2012* | <5.0 | U | 2,300 | | <5.0 | U | <5.0 | U | 2,300 | |
| 10/23/2012 | <1.0 | U | 1,200 | | 2.4 | | <1.0 | U | 1,202 | |
| 11/29/2012 | <4.0 | U | 2,200 | | <4.0 | U | <4.0 | U | 2,200 | |
| 2/27/2013 | <4.0 | U | 2,800 | | 4.1 | | 4.3 | | 2,808 | |
| 5/21/2012 | <10 | U | 3,100 | | <10 | U | <10 | U | 3,100 | |
| 8/27/2013 | 0.2 | | 720 | | 1.7 | | 0.7 | | 723 | |
| 1/14/2014 | <0.4 | U | 180 | | 0.5 | | <0.4 | U | 181 | |
| 4/29/2014 | <2.0 | U | 750 | | <2.0 | U | <2.0 | u | 750 | |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | <1.0 | U | <1.0 | U | 180 | | 3.9 | |
| 10/23/2012 | <1.0 | U | <1.0 | U | 110 | | 3.6 | |
| 11/29/2012 | <5.0 | U | <5.0 | U | 71 | | 5 | |
| 2/27/2013 | <5.0 | U | <5.0 | U | 330 | | 4.4 | |
| 5/21/1931 | <5.0 | U | <5.0 | U | 310 | | 4.7 | |
| 8/27/2013 | <5.0 | U | <5.0 | U | 130 | | NS | |
| 1/14/2014 | <5.0 | U | <5.0 | U | 110 | | NS | |
| 4/29/2014 | <5.0 | U | <5.0 | U | 280 | | NS | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

| | |
|---|---|
| CVOC | Chlorinated volatile organic compound |
| DCE | Dichloroethene |
| PCE | Tetrachloroethene |
| TCE | Trichloroethene |
| TOC | Total Organic Carbon |
| VC | Vinyl chloride |

Qualifiers:

| | |
|---|---|
| U | Non-detect |
| J | Estimated |

Performance Monitoring Data from Well PL2-258A

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2/10/2010 | <1 | U | <1 | U | 2.3 | | 300 | | 302 | |
| 3/10/2010 | 0.2 | U | 28 | | 20 | | 1,500 | | 1,548 | |
| 8/6/2010 | <1 | U | <1 | U | 1.6 | | 180 | | 182 | |
| 2/3/2011 | <2 | U | 78 | | 62 | | 1000 | | 1,140 | |
| 8/18/2011 | <4 | U | 87 | | 39 | | 940 | | 1,066 | |
| 2/7/2012 | <.2 | U | 21 | | 27 | | 550 | | 598 | |
| 8/7/2012 | <.2 | U | 80 | | 27 | | 600 | | 707 | |
| 1/8/2013* | 0.2 | | 8.6 | | 11 | | 230 | | 250 | |
| 5/22/2013 | <0.2 | U | 2 | | <0.2 | U | 37 | | 39 | |
| 8/27/2013 | <0.2 | U | 0.5 | | <0.2 | U | 19 | | 20 | |
| 1/15/2014 | <0.2 | U | 1.1 | | <0.2 | U | 59 | | 60 | |
| 4/29/2014 | <0.2 | U | <0.2 | U | <0.2 | U | 0.9 | | 0.9 | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

- CVOC Chlorinated volatile organic compound
- DCE Dichloroethene
- PCE Tetrachloroethene
- TCE Trichloroethene
- VC Vinyl chloride

Qualifiers:

- U Non-detect
- J Estimated

Performance Monitoring Data from Well PL2-258B

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2/10/2010 | <1 | U | 50 | | <1 | U | <1 | U | 50.0 | |
| 3/10/2010 | 0.5 | | 42 | | 0.5 | | 0.7 | | 43.7 | |
| 8/6/2010 | <1 | U | 81 | | <1 | U | <1 | U | 81.0 | |
| 2/3/2011 | 0.4 | | 11 | | 0.3 | | 0.2 | | 11.9 | |
| 8/18/2011 | 0.4 | | 13 | | 0.4 | | 0.2 | | 14.0 | |
| 2/7/2012 | 0.4 | | 2.6 | | 0.6 | | <0.2 | U | 3.6 | |
| 8/7/2012 | 0.4 | | 2.7 | | 1.1 | | <0.2 | U | 4.2 | |
| 1/8/2013* | 1.5 | | 5.5 | | 0.6 | | 0.8 | | 8.4 | |
| 5/22/2013 | 4.9 | | 45 | | <2.5 | U | 2.7 | | 52.6 | |
| 8/27/2013 | 2.9 | | 49 | | 0.9 | | 3.6 | | 56.4 | |
| 1/15/2014 | 0.7 | | 13 | | 0.6 | | 6.3 | | 20.6 | |
| 4/29/2014 | 0.3 | | 2.4 | | <0.2 | U | 0.8 | | 3.5 | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated

Performance Monitoring Data from Well IW-N-1

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | <0.1 | U | 1.1 | | 0.5 | | 1.4 | | 3 | |
| 10/24/2012 | <1.0 | U | <1.0 | U | <1.0 | U | <1.0 | U | <1.0 | U |
| 11/30/2012 | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U |
| 2/26/2013 | <100 | U | <100 | U | <100 | U | <100 | U | <100 | U |
| 5/21/2013 | <4.0 | U | <4.0 | U | <4.0 | U | <4.0 | U | <4.0 | U |
| 8/27/2013 | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U |
| 1/14/2014 | <1.0 | U | <1.0 | U | <1.0 | U | <1.0 | U | <1.0 | U |
| 4/29/2014 | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | <20 | U | <20 | U | 1,300 | | 8.7 | |
| 10/24/2012 | <1.0 | U | <1.0 | U | 380 | | 6,430 | |
| 11/30/2012 | <5.0 | U | <5.0 | U | 2,500 | | 799 | |
| 2/26/2013 | <5.0 | U | <5.0 | U | 11,000 | | 5,490 | |
| 5/21/2013 | <5.0 | U | <5.0 | U | 20,000 | | 1,520 | |
| 8/27/2013 | NS | | NS | | NS | | 1,790 | |
| 1/14/2014 | NS | | NS | | NS | | 26.8 | |
| 4/29/2014 | NS | | NS | | NS | | 8.4 | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
TOC Total Organic Carbon
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated

Performance Monitoring Data from Well IW-N-4

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | <1.0 | U | 3.9 | | <1.0 | U | 11 | | 15 | |
| 10/24/2012 | <1.0 | U | 1.2 | J | <1.0 | U | <1.0 | U | 1.2 | |
| 11/30/2012 | <1.0 | U | 4.6 | | <1.0 | U | 3.6 | | 8.2 | |
| 2/27/2013 | <1.0 | U | 4.3 | | <1.0 | U | 2.9 | | 7.2 | |
| 5/21/2013 | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U |
| 8/28/2013 | 1.2 | | 3.2 | | <1.0 | U | 2.9 | | 7.3 | |
| 1/14/2014 | <0.2 | U | 0.4 | | <0.2 | U | 0.5 | | 0.9 | |
| 4/30/2014 | <0.2 | U | 0.3 | | 0.4 | | <0.2 | U | 0.7 | |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | <200 | U | <200 | U | 19,000 | | 55.1 | |
| 10/24/2012 | <100 | U | <100 | U | 8,600 | | 2,020 | |
| 11/30/2012 | <5.0 | U | <5.0 | U | 33,000 | | 433 | |
| 2/27/2013 | <5.0 | U | <5.0 | U | 32,000 | | 2,250 | |
| 5/21/2013 | <5.0 | U | <5.0 | U | 31,000 | | 183 | |
| 8/28/2013 | NS | | NS | | NS | | 1,180 | |
| 1/14/2014 | NS | | NS | | NS | | 13.3 | |
| 4/30/2014 | NS | | NS | | NS | | 22.9 | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
TOC Total Organic Carbon
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated

Performance Monitoring Data from Well IW-N-5

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | 19 | | 23.0 | | 0.3 | | 0.9 | | 43.2 | |
| 10/24/2012 | 10 | | 9.7 | | <1.0 | U | <1.0 | U | 19.7 | |
| 11/30/2012 | 8.1 | | 3.6 | | <1.0 | U | <1.0 | U | 11.7 | |
| 2/27/2013 | 5.8 | | 9.2 | | <4.0 | U | 8.5 | | 23.5 | |
| 5/21/2013 | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U |
| 8/27/2013 | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U |
| 1/14/2014 | <0.2 | U | 0.2 | | <0.2 | U | <0.2 | U | 0.2 | |
| 4/29/2014 | <0.2 | U | 0.2 | | <0.2 | U | <0.2 | U | 0.2 | |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | <1.0 | U | <1.0 | U | 42 | | 41.6 | |
| 10/24/2012 | <1.0 | U | <1.0 | U | 21 | | 5,910 | |
| 11/30/2012 | <5.0 | U | <5.0 | U | 890 | | 3.6 | |
| 2/27/2013 | <5.0 | U | <5.0 | U | 12,000 | | 1,330 | |
| 5/21/2013 | <5.0 | U | <5.0 | U | 20,000 | | 136 | |
| 8/27/2013 | NS | | NS | | NS | | 407 | |
| 1/14/2014 | NS | | NS | | NS | | 11.2 | |
| 4/29/2014 | NS | | NS | | NS | | 8.9 | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
TOC Total Organic Carbon
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated

Performance Monitoring Data from Well IW-N-6

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | 23 | | 490 | | 8.1 | | 11 | | 532 | |
| 10/24/2012 | 120 | | 85 | | <5.0 | U | <5.0 | U | 205 | |
| 11/30/2012 | 48 | | 1,300 | | 20 | | 30 | | 1,348 | |
| 2/26/2013 | 430 | | 3,200 | | 54 | | 62 | | 3,746 | |
| 5/21/2013 | 68 | | 1,600 | | 22 | | 140 | | 1,830 | |
| 8/27/2013 | 20 | | 530 | | 11 | | 170 | | 731 | |
| 1/14/2014 | 0.6 | | 7.4 | | <0.5 | U | 26 | | 34 | |
| 4/29/2014 | 0.2 | | 4.5 | | 0.4 | | 33 | | 38 | |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | 3.2 | J | <1.0 | U | 13,000 | | 10.2 | |
| 10/24/2012 | <1.0 | U | <1.0 | U | 1,500 | | 8,830 | |
| 11/30/2012 | <5.0 | U | <5.0 | U | 13,000 | | 204 | |
| 2/26/2013 | <5.0 | U | <5.0 | U | 13,000 | | 3,240 | |
| 5/21/2013 | <5.0 | U | 7.4 | | 23,000 | | 1,780 | |
| 8/27/2013 | NS | | NS | | NS | | 699 | |
| 1/14/2014 | NS | | NS | | NS | | 23.9 | |
| 4/29/2014 | NS | | NS | | NS | | 13.0 | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
TOC Total Organic Carbon
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated

Performance Monitoring Data from Well PL2-209A

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3/17/2010 | 1.1 | | 42 | | 0.2 | | 26 | | 69 | |
| 9/20/2012* | 2.3 | | 27 | | 0.1 | J | 20 | | 49 | |
| 10/23/2012 | 1 | | 6.5 | | <0.1 | U | 10 | | 18 | |
| 11/29/2012 | 1.4 | | 2.9 | | <0.2 | U | 3.1 | | 7 | |
| 2/26/2013 | 1.2 | | 24 | | <0.2 | U | 22 | | 47 | |
| 5/21/2013 | 0.4 | | 15 | | <0.2 | U | 18 | | 33 | |
| 8/28/2013 | <0.2 | U | 8.5 | | <0.2 | U | 18 | | 27 | |
| 1/14/2014 | <0.2 | U | 1.4 | | <0.2 | U | 4.4 | | 6 | |
| 4/29/2014 | 0.3 | | 3.1 | | <0.2 | U | 4.8 | | 8 | |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | 2.8 | J | <1.0 | U | 380 | | 10.2 | |
| 10/23/2012 | 3.5 | J | <1.0 | U | 4,300 | | 9.8 | |
| 11/29/2012 | <5.0 | U | <5.0 | U | 3,500 | | 7 | |
| 2/26/2013 | <5.0 | U | <5.0 | U | 5,200 | | 9 | |
| 5/21/2013 | <5.0 | U | <5.0 | U | 12,000 | | 9.7 | |
| 8/28/2013 | <5.0 | U | <5.0 | U | 11,000 | | NS | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
TOC Total Organic Carbon
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated

Performance Monitoring Data from Well PL2-209B

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3/17/2010 | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U |
| 9/20/2012* | <0.5 | U | <0.5 | U | <0.5 | U | <0.5 | U | <0.5 | U |
| 10/23/2012 | <0.5 | U | <0.5 | U | <0.5 | U | <0.5 | U | <0.5 | U |
| 11/29/2012 | <1.0 | U | <1.0 | U | <1.0 | U | <1.0 | U | <1.0 | U |
| 2/26/2013 | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U |
| 5/21/2013 | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U |
| 8/28/2013 | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U |
| 1/14/2014 | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U |
| 4/29/2014 | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | 3.4 | J | <1.0 | U | 13,000 | | 370 | |
| 10/23/2012 | <1.0 | U | <1.0 | U | 21,000 | | 279 | |
| 11/29/2012 | <5.0 | U | <5.0 | U | 28,000 | | 18.9 | |
| 2/26/2012 | <5.0 | U | <5.0 | U | 21,000 | | 6.6 | |
| 5/21/2013 | <5.0 | U | <5.0 | U | 25,000 | | 8.6 | |
| 8/28/2013 | <5.0 | U | <5.0 | U | 24,000 | | NS | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
TOC Total Organic Carbon
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated

Performance Monitoring Data from Well PL2-253A

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3/12/2010 | <0.2 | U | 15 | | 0.8 | | 91 | | 106 | |
| 5/22/2013* | <0.2 | U | 0.4 | | 0.3 | | 6.8 | | 8 | |
| 8/28/2013 | <0.2 | U | <0.2 | U | 0.2 | | 2.0 | | 2.2 | |
| 1/14/2014 | <0.2 | U | 0.3 | | 0.2 | | 0.7 | | 1.2 | |
| 4/30/2014 | <0.2 | U | <0.2 | U | <0.2 | U | 0.2 | | 0.2 | |

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 5/22/2013 | 5.8 | | <5.0 | U | 18,000 | | 10 | |
| 8/28/2013 | 6.6 | | <5.0 | U | 15,000 | | NS | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
TOC Total Organic Carbon
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated

Performance Monitoring Data from Well PL2-257A

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3/9/2010 | 20 | | 52 | | 1 | | 3.9 | | 77 | |
| 9/20/2012* | 22 | | 31 | | 0.6 | | 1.1 | | 55 | |
| 10/23/2012 | 6.1 | | 31 | | <1.0 | | 1.7 | | 39 | |
| 11/29/2012 | 12 | | 32 | | 0.7 | | 3.5 | | 48 | |
| 5/22/2013 | 17 | | 36 | | 0.7 | | 2.0 | | 56 | |
| 8/28/2013 | 10 | | 34 | | 0.7 | | 3.5 | | 48 | |
| 1/15/2014 | 4 | | 36 | | 0.7 | | 5.3 | | 46 | |
| 4/30/2014 | 1 | | 37 | | 0.5 | | 5.0 | | 44 | |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | <1.0 | U | <1.0 | U | 14 | J | 7.6 | |
| 10/23/2012 | <1.0 | U | <1.0 | U | 1,100 | | 8.9 | |
| 11/29/2012 | <5.0 | U | <5.0 | U | 63 | | 9.0 | |
| 5/22/2013 | <5.0 | U | <5.0 | U | 2,200 | | 8.3 | |
| 8/28/2013 | NS | | NS | | NS | | NS | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
TOC Total Organic Carbon
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated

Performance Monitoring Data from Well PL2-256A

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3/12/2010 | <0.2 | U | 0.3 | | <0.2 | U | 0.7 | | 1 | |
| 9/20/2012* | 1 | | 2.9 | | <0.1 | U | 2.5 | | 6.4 | |
| 10/23/2012 | <1.0 | U | <1.0 | U | <1.0 | U | <1.0 | U | <1.0 | U |
| 11/29/2012 | 1.3 | | 0.3 | | <0.2 | U | 0.7 | | 2.3 | |
| 2/27/2013 | 1.0 | | 0.4 | | <0.2 | U | 0.4 | | 1.8 | |
| 5/22/2013 | 0.3 | | <2.0 | U | <2.0 | U | <2.0 | U | 0.3 | |
| 8/28/2013 | <0.2 | U | <2.0 | U | <2.0 | U | 0.3 | | 0.3 | |
| 1/15/2014 | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U |
| 4/30/2014 | <0.2 | U | <0.2 | U | <0.2 | U | 0.5 | | 0.5 | |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | <10 | U | <10 | U | 1,500 | | 5.5 | |
| 10/23/2012 | <10 | U | <10 | U | 2,500 | | 11.9 | |
| 11/29/2012 | <5.0 | U | <5.0 | U | 1,400 | | 6.3 | |
| 2/27/2013 | <5.0 | U | <5.0 | U | 2,200 | | 5.5 | |
| 5/22/2013 | <5.0 | U | <5.0 | U | 1,800 | | 4.9 | |
| 8/28/2013 | <5.0 | U | <5.0 | U | 1,600 | | NS | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

| | |
|---|---|
| CVOC | Chlorinated volatile organic compound |
| DCE | Dichloroethene |
| PCE | Tetrachloroethene |
| TCE | Trichloroethene |
| TOC | Total Organic Carbon |
| VC | Vinyl chloride |

Qualifiers:

| | |
|---|---|
| U | Non-detect |
| J | Estimated |

Performance Monitoring Data from Well IW-S-12

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | 5.9 | | 5.5 | | 0.3 | | 1.2 | | 12.9 | |
| 10/24/2012 | 3.7 | | 1.7 | J | <1.0 | U | <1.0 | U | 5.4 | |
| 11/30/2012 | 4.1 | | 4.2 | | <2.0 | U | <2.0 | U | 8.3 | |
| 2/27/2013 | 8.8 | | 14 | | <1.0 | U | 3.3 | | 26.1 | |
| 5/22/2013 | 3.3 | | 11 | | <1.0 | U | <1.0 | U | 14.3 | |
| 8/28/2013 | <20 | U | <20 | U | <20 | U | <20 | U | <20 | U |
| 1/15/2014 | <1.0 | U | <1.0 | U | <1.0 | U | <1.0 | U | <1.0 | U |
| 4/30/2014 | 0.4 | | 1 | | <0.2 | U | <0.2 | U | 1.4 | |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | <10 | U | <10 | U | 1,300 | | 10.8 | |
| 10/24/2012 | <10 | U | <10 | U | 1,500 | | 5,830 | |
| 11/30/2012 | <5.0 | U | <5.0 | U | 2,100 | | 281 | |
| 2/27/2013 | <5.0 | U | <5.0 | U | 7,100 | | 4,770 | |
| 5/22/2013 | <5.0 | U | <5.0 | U | 20,000 | | 1,520 | |
| 8/28/2013 | NS | | NS | | NS | | 9,200 | |
| 1/15/2014 | NS | | NS | | NS | | 610 | |
| 4/30/2014 | NS | | NS | | NS | | 20 | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

- CVOC Chlorinated volatile organic compound
- DCE Dichloroethene
- PCE Tetrachloroethene
- TCE Trichloroethene
- TOC Total Organic Carbon
- VC Vinyl chloride

Qualifiers:

- U Non-detect
- J Estimated

Performance Monitoring Data from Well IW-S-13

| Sample Date | TCE (ug/L) | | cis-DCE (ug/L) | | trans-DCE (ug/L) | | VC (ug/L) | | Total CVOCs (ug/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | 0.6 | | 4 | | <1.0 | U | 2 | | 6.6 | |
| 10/24/2012 | 1.2 | J | <1.0 | U | <1.0 | U | <1.0 | U | 1.2 | |
| 11/30/2012 | 2.6 | | <2.0 | U | <2.0 | U | <2.0 | U | 2.6 | |
| 2/26/2013 | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U |
| 5/22/2013 | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U |
| 8/28/2013 | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U | <2.0 | U |
| 1/15/2014 | <0.4 | U | <0.4 | U | <0.4 | U | <0.4 | U | <0.4 | U |
| 4/30/2014 | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U | <0.2 | U |

* Indicates first sampling event after the start of substrate injections for ERD.

| Sample Date | Ethane (ug/L) | | Ethene (ug/L) | | Methane (ug/L) | | TOC (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| 9/20/2012* | <50 | U | <50 | U | 3,800 | | 42.2 | |
| 10/24/2012 | <1.0 | U | <1.0 | U | 79 | | 3,750 | |
| 11/30/2012 | <5.0 | U | <5.0 | U | 11,000 | | 227 | |
| 2/26/2013 | <5.0 | U | <5.0 | U | 24,000 | | 2,530 | |
| 5/22/2013 | <5.0 | U | <5.0 | U | 21,000 | | 434 | |
| 8/28/2013 | <5.0 | U | <5.0 | U | 25,000 | | 1,800 | |
| 1/15/2014 | NS | | NS | | NS | | 291 | |
| 4/30/2014 | NS | | NS | | NS | | 9.9 | |

* Indicates first sampling event after the start of substrate injections for ERD.

Abbreviations:

| | |
|---|---|
| CVOC | Chlorinated volatile organic compound |
| DCE | Dichloroethene |
| PCE | Tetrachloroethene |
| TCE | Trichloroethene |
| TOC | Total Organic Carbon |
| VC | Vinyl chloride |

Qualifiers:

| | |
|---|---|
| U | Non-detect |
| J | Estimated |

**Boeing Plant 2**
**Seattle/Tukwila, Washington**

# Remedial Optimization for the 2-10 Interim Measures

# Technical Memorandum

# Appendix B
# Conceptual Site Model and Historical Monitoring Data for IM Planning

**Agency Review Draft**

**Summary of Conceptual Site Model (CSM)**
**Volatile Organic Compound Plumes near the 2-10 Area Sheetpiles**

*Source, adapted from:*
*CALIBRE and Floyd|Snider. 2009. Interim Measure Work Plan for the North and South Sheetpiles in the 2-10 Building Area (AOC 2-10.3A and AOC 2-10.4A) Phase 1: Data Collection. Prepared for The Boeing Company. Prepared by CALIBRE Systems and Floyd|Snider, Bellevue, Washington. June.*

**Summary of Conceptual Site Model (CSM)**
**Volatile Organic Compound Plumes near the 2-10 Area Sheetpiles**

| CSM Element | Conditions Considered within the Conceptual Site Model |
|---|---|
| **History and Background**<br>(Weston 1996) | • The 2-10 facility was used for aircraft production starting in the 1940s. Equipment included four vapor degreasers in three discrete locations that were decommissioned and removed in 1993. Degreasers were installed with secondary containment including sumps.<br>• Sheetpile walls were installed beneath the 2-10 Building as an interim measure to encompass most of the contaminant mass in the two plumes (the source area and a portion of the volatile organic compound [VOC] plumes) at the two main degreaser locations in 1994. Physical access constraints within the building resulted in small areas of both plume areas remaining outside the sheetpile walls.<br>• An effectiveness evaluation in 2001 concluded the sheetpile walls were effective at containing the VOC plumes. |
| **Setting and Boundaries**<br>(Weston 1996; Weston 2001) | • Present land use continues to support aircraft production activities, with all major portions of the existing plumes lying beneath Building 2-10. Current building activities include small-scale manufacturing, parts testing, shipping/receiving functions, and storage.<br>• Soil and groundwater contamination by VOCs is concentrated (and bounded) in two areas associated with decommissioned vapor degreasers: designated as AOC 2-10.3A North (the 2-10 north sheetpile) and AOC 2-10.4A South (the 2-10 south sheetpile).<br>• The AOC 2-10.3A North plume covers an area approximately 450 feet (SW to NE in the direction of groundwater flow) by 250 feet (NW to SE in direction transverse to groundwater flow) beneath the north end of Building 2-10. The general footprint of the plume (approximately 450 by 250 feet) remains similar from 1992 to 2008; however, groundwater concentrations have attenuated during that time.<br>• The AOC 2-10.4A South plume covers an area approximately 250 feet (SW to NE in the direction of groundwater flow) by 150 feet (NW to SE in direction transverse to groundwater flow) beneath the north end of Building 2-10. The general footprint of the plume (approximately 250 by 150 feet) remains similar from 1992 to 2008; however, groundwater concentrations have attenuated during that time. |

| CSM Element | Conditions Considered within the Conceptual Site Model |
|---|---|
| **Geology and Hydrogeology**<br>(Weston 1996; Weston 2001; EPI and Golder, 2009) | • Underlying soil matrix is alluvium deposited within a river valley, consisting of inter-bedded silts and sands. Locally, silty sand/sand extends to approximately 90 feet below ground surface (bgs).<br>• Uppermost aquifer begins 10 feet bgs and extends to 80 to 100 feet bgs in this area. Discontinuous silt zones exist, especially at depth; a thick valley-wide aquitard exists at 80 to 100 feet bgs composed of very fine-grained marine and estuarine muds.<br>• Below approximately 60 feet bgs, the aquifer is saline due to its original formation as a marine embayment. A saline wedge also exists to the top of the aquifer near the Lower Duwamish Waterway.<br>• Groundwater flows west toward, and discharges to, the Lower Duwamish Waterway, a tidally influenced man-made waterway connected to Elliott Bay in Puget Sound. Fresh water discharges tend to occur up and over the salt water wedge in the aquifer.<br>• For investigation purposes, this uppermost aquifer has been divided into three levels: A (shallow), B (intermediate), and C (deeper). There is limited mixing between the upper two levels (A and B) and the lower C zone, which is saline.<br>• The Lower Duwamish Waterway is a tidally influenced river estuary, with fresh river water discharging above a tidally influenced saltwater wedge from Elliott Bay. Tidal influence is seen in the aquifer for 300 to 600 feet inland with decreasing amplitude and increasing time lag.<br>• Installation of sheetpiles isolated the bulk of the VOC plumes. Both sheetpiles are hanging walls that are not tied into a lower permeability formation or aquitard. Detailed analysis of potentiometric heads by Weston (including density differences and tidally averaged conditions) resulted in the conclusion that net vertical gradients at depth are upward to discharge into the Lower Duwamish Waterway.<br>• The roof and floor slab of Building 2-10 cap the site, thus eliminating recharge from rainfall. As a consequence, within the sheetpile enclosures, vertical movement is restricted primarily to tidal cycle pressure fluctuations and, beyond the sheetpiles near the waterway, some bank storage effect as the surface water moves in and out with the tides in the Lower Duwamish Waterway. |

| CSM Element | Conditions Considered within the Conceptual Site Model |
|---|---|
| **Source(s) of Chemical Release**<br>(Weston 1992) | • Trichloroethene (TCE) was used as the degreasing agent in the sheetpile area degreasers where releases have been identified (based on empirical data of TCE found in soil and groundwater).<br>• The location and characteristics of the residual TCE suggest the releases were from within the degreaser pits, and traveled down to 20 to 30 feet bgs. Below approximately 30 feet bgs, concentrations drop quickly to the low and sub parts per billion range.<br>• TCE residues in saturated soils act as an on-going release to groundwater through leaching.<br>• TCE residues in the unsaturated soils (vadose zone) act as an on-going release to soil vapor beneath the 2-10 Building, which has the potential to intrude into the building through cracks in the foundation. (*Note: Indoor air sampling data, presented in following section, indicate that although the potential for intrusion exists, concentrations are protective of industrial workers).*<br>• TCE residues are naturally degrading to form dichloroethenes (DCE) and vinyl chloride (VC). VC is further degrading to form non-toxic end-products. |
| **Chemicals of Concern**<br>(Weston 1996) | • TCE and its degradation products, 1,1-DCE, 1,2-DCE (both cis-and trans- isomers), and VC have been detected in site soil and groundwater at the northern plume.<br>• TCE and its degradation products, 1,1-DCE, 1,2-DCE (both cis- and trans- isomers) and VC have been detected in site soil and groundwater at the southern plume. Much lower levels of 1,1,2-trichloroethane have also been observed in the southern plume.<br>• TCE is documented as the degreasing solvent used at Plant 2 and there is no evidence of use of DCE or VC in the facility, suggesting that these chemicals are by-products of natural reductive dechlorination mechanisms in the subsurface environment. |

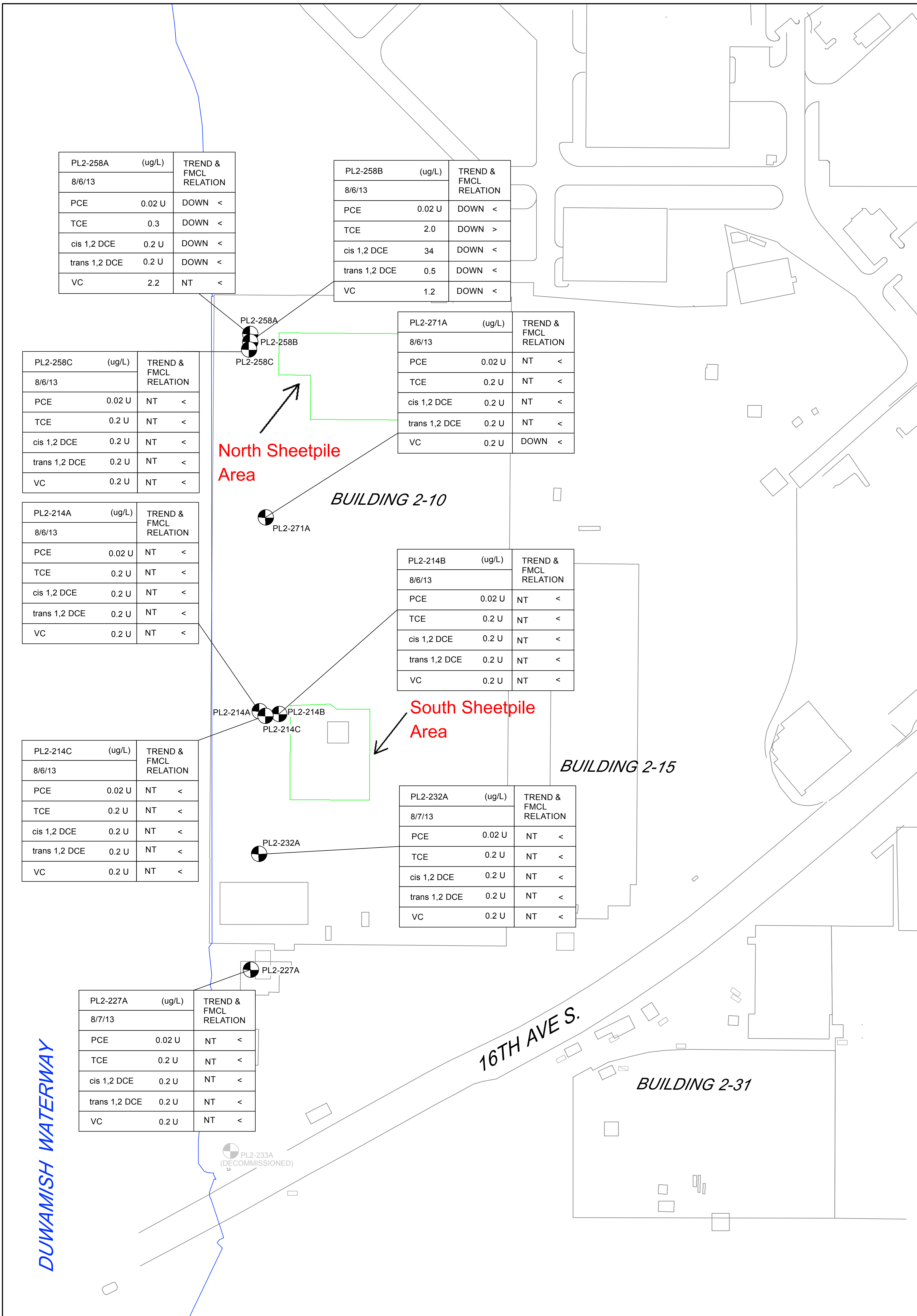
| CSM Element | Conditions Considered within the Conceptual Site Model |
|---|---|
| **The Potential For DNAPL Occurrence** | • The initial TCE concentrations in groundwater (highest) were 420,000 micrograms per liter (µg/L) and 32,000 µg/L in 1992 for the north and south plumes, respectively. These values are consistent with either loss of pure phase solvent (a dense non-aqueous phase liquid [DNAPL]) or discharge of the saturated solution from the degreaser water separator. If the former were the source (i.e., loss of pure phase solvent), DNAPL would be expected and high dissolved concentrations would persist over time. If the latter were the source (i.e., release of a saturated aqueous solution), the concentrations would diminish faster over time due to natural degradation.<br>• The 1992 characterization data (relevant to evaluating the potential presence of DNAPL) indicated high concentrations in the shallow zone near the water table and decreasing concentrations at deeper depths. The 1992 investigations did not extend to the point of contact with the aquitard below the C level of the aquifer. Later (in 1995), a C-zone well was installed extending to the point of contact with the aquitard below the C-zone just down gradient of the north sheetpile (PL2-258C). In 2001 a similar C-zone well was installed at the south sheetpile (PL2-214C extending to the point of contact with the aquitard below the C-zone). Well PL2-258C has been sampled 21 times over the last 14 years and TCE has been non-detectable in all samples with detection limits between 0.2 and 1.0 µg/L. Likewise, well PL2-214C has been sampled 15 times over the last 8 years and all results for TCE are non-detect with detection limits between 0.2 and 1.0 µg/L depending on event. Based on these results, there is no indication of DNAPL occurrence at the base of the aquifer.<br>• No DNAPL has been observed to date in any of the borings or investigation samples.<br>• Prior to the start of the current interim measures, TCE concentrations in groundwater had decreased since 1992, even though no active remedial action had been implemented until 2012 (within the 2-10 Building sheetpile areas). Prior to beginning the current interim measures, groundwater, soil, and vapors were resampled to assess “current” conditions. In the south sheetpile area, TCE concentrations were no longer sufficiently high to indicate the presence of DNAPL. In the north sheetpile area, TCE concentrations were at 5.6 percent of TCE solubility (as of 2010) and may indicate the presence of DNAPL that would be present at depths from approximately 10 to 25 feet bgs (possibly as a trapped ganglia). It is also possible that the observed concentrations are due to the release of a saturated aqueous solution (from the degreaser water separators), rather than a release of free product TCE. Since the start of the interim measure groundwater treatment (beginning in 2012), TCE concentrations have declined to under 1 µg/L in the source area well (PL2-212A at 0.3 µg/L TCE in April 2014). |

| CSM Element | Conditions Considered within the Conceptual Site Model |
|---|---|
| **Fate and Transport Pathways** (Weston 2000; Trend Analysis of VOC Data from Boeing Plant 2 Database) | • Primary attenuation of TCE is through biological and chemical degradation by reductive dechlorination; secondary attenuation, especially in the vadose zone, includes volatilization. Convective transport in groundwater is limited due to the effect of the hanging wall as demonstrated in the 2001 effectiveness evaluation (Weston 2001).<br>• Degradation is ongoing with production of cis-1,2-DCE (predominant isomer) and trans-1,2-DCE (at much lower concentrations), followed by their degradation to VC; data collected as part of the Interim Action confirmed that the VC was being further reduced to the non-toxic ethene.<br>• Volatilized chlorinated ethenes (TCE and its degradation products) could potentially volatilize from the vadose soils or from shallow groundwater and enter the overlying 2-10 Building. Once in the air, a host of oxidative, hydrolytic, and photolytic processes take over to degrade the compounds within hours to days (http://www.epa.gov/ttn/atw/hlthef/tri-ethy.html; Agency for Toxic Substances and Disease Registry [ATSDR] *Toxicological Profile for Trichloroethylene [Update]*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1997). Indoor air sampling (discussed in the next section) confirms that concentrations in the indoor air are protective of industrial workers.<br>• Chlorinated ethenes in groundwater outside the sheetpiles will migrate toward the waterway and discharge in the Lower Duwamish Waterway. Travel distances range from 50 to 200 feet.<br>• The bulk of the residual chlorinated ethenes is present in soil and groundwater contained within the sheetpile structures.<br>• Reductive dechlorination processes benefit from the low dissolved oxygen and reducing conditions in the groundwater within the sheetpile structures. A best fit of degradation rates (1994 to 2002) for the reduction of total chlorinated ethenes yields rate constants of -0.0003 to -0.008 day$^{-1}$ inside and around the north sheetpile enclosure. Calculated degradation rate constants inside and around the south sheetpile are -0.0005 to -0.002 day$^{-1}$. Note that these are pre-Interim Action rates. The calculated rates for the 2-10 Building VOC plumes are comparable to what has been observed at the Electronic Manufacturing Facility VOC plume prior to addition of substrate to accelerate reductive dechlorination. |

| CSM Element | Conditions Considered within the Conceptual Site Model |
|---|---|
| **Exposure Pathways**<br>(Weston 2001; Golder 2010; EPI 2013) | • Vapor intrusion into the 2-10 Building is a potential exposure pathway under current site conditions. Indoor air was sampled in December 2009 under a USEPA-approved Work Plan. Tetrachloroethylene (PCE), TCE, and VC were detected in indoor air samples; PCE was also detected in background, outdoor air samples. None of the detections exceeded the indoor air cleanup levels developed by USEPA for Plant 2 to protect worker exposures.<br>• The installation (and associated monitoring program) of the sheetpiles has controlled the groundwater discharge of the majority of the released chlorinated ethenes to the waterway (Weston 2001). The 2013 Shoreline Monitoring indicates that concentrations downgradient of the north sheetpile (the PL2-258 triplet) are in compliance except for TCE in the B-zone, which is less than 2 times the final media cleanup level. Groundwater downgradient of the south sheetpile (the PL2-214 triplet) is fully in compliance.<br>• Incomplete exposure pathways (based on present land use) include soil and on-site surface water drainage. |
| **Corrective Measures Implemented prior to the current (2013) IA**<br>(Weston 2001) | • The north sheetpile structure was installed in 1994 to contain a plume associated with Resource Conservation and Recovery Act (RCRA) Unit AOC 2-10.3A North (the 2-10 north sheetpile). The structure extends from near the ground surface to a depth of 30 feet bgs.<br>• The south sheetpile structure was installed in 1994 to contain a plume associated with RCRA Unit AOC 2-10.3A South (the 2-10 south sheetpile). The structure extends from near the ground surface to a depth of 25 feet bgs.<br>• Long-term downgradient groundwater monitoring has been performed as part of the Shoreline Monitoring Program since 2001. |
| **Performance Metrics** | • Containment evaluation in 2001 concluded contaminants were not migrating out of the enclosures in groundwater.<br>• The 2008–2009 Data Gaps Investigation (Golder 2009) determined that indoor air was acceptable even before the current interim measure.<br>• Performance metrics for the interim measure include:<br>1. Can the degradation/removal rate be accelerated?<br>2. Is the contaminant mass declining at a rate that will eliminate unacceptable risk (as measured by indoor air and groundwater discharge) within a reasonable timeframe?<br>3. Do the interim measure performance data support a final corrective measure decision?<br>4. Can the residual mass in the source areas that is contained by the sheetpiles be reduced sufficiently to allow for no long-term maintenance requirements for the sheetpile structures? |

***Selected pages from:***

*EPI. 2013. CMS Phase Semiannual Shoreline Groundwater Monitoring Report, August 2013 Boeing Plant 2 Seattle/Tukwila, Washington. Prepared for The Boeing Company. Prepared by Environmental Partners Inc. 24 October.*




| PL2-258A (ug/L) | | TREND & FMCL RELATION | |
|---|---|---|---|
| 8/6/13 | | | |
| PCE | 0.02 U | DOWN | < |
| TCE | 0.3 | DOWN | < |
| cis 1,2 DCE | 0.2 U | DOWN | < |
| trans 1,2 DCE | 0.2 U | DOWN | < |
| VC | 2.2 | NT | < |

| PL2-258B (ug/L) | | TREND & FMCL RELATION | |
|---|---|---|---|
| 8/6/13 | | | |
| PCE | 0.02 U | DOWN | < |
| TCE | 2.0 | DOWN | > |
| cis 1,2 DCE | 34 | DOWN | < |
| trans 1,2 DCE | 0.5 | DOWN | < |
| VC | 1.2 | DOWN | < |

| PL2-271A (ug/L) | | TREND & FMCL RELATION | |
|---|---|---|---|
| 8/6/13 | | | |
| PCE | 0.02 U | NT | < |
| TCE | 0.2 U | NT | < |
| cis 1,2 DCE | 0.2 U | NT | < |
| trans 1,2 DCE | 0.2 U | NT | < |
| VC | 0.2 U | DOWN | < |

| PL2-258C (ug/L) | | TREND & FMCL RELATION | |
|---|---|---|---|
| 8/6/13 | | | |
| PCE | 0.02 U | NT | < |
| TCE | 0.2 U | NT | < |
| cis 1,2 DCE | 0.2 U | NT | < |
| trans 1,2 DCE | 0.2 U | NT | < |
| VC | 0.2 U | NT | < |

| PL2-214A (ug/L) | | TREND & FMCL RELATION | |
|---|---|---|---|
| 8/6/13 | | | |
| PCE | 0.02 U | NT | < |
| TCE | 0.2 U | NT | < |
| cis 1,2 DCE | 0.2 U | NT | < |
| trans 1,2 DCE | 0.2 U | NT | < |
| VC | 0.2 U | NT | < |

| PL2-214B (ug/L) | | TREND & FMCL RELATION | |
|---|---|---|---|
| 8/6/13 | | | |
| PCE | 0.02 U | NT | < |
| TCE | 0.2 U | NT | < |
| cis 1,2 DCE | 0.2 U | NT | < |
| trans 1,2 DCE | 0.2 U | NT | < |
| VC | 0.2 U | NT | < |

| PL2-214C (ug/L) | | TREND & FMCL RELATION | |
|---|---|---|---|
| 8/6/13 | | | |
| PCE | 0.02 U | NT | < |
| TCE | 0.2 U | NT | < |
| cis 1,2 DCE | 0.2 U | NT | < |
| trans 1,2 DCE | 0.2 U | NT | < |
| VC | 0.2 U | NT | < |

| PL2-232A (ug/L) | | TREND & FMCL RELATION | |
|---|---|---|---|
| 8/7/13 | | | |
| PCE | 0.02 U | NT | < |
| TCE | 0.2 U | NT | < |
| cis 1,2 DCE | 0.2 U | NT | < |
| trans 1,2 DCE | 0.2 U | NT | < |
| VC | 0.2 U | NT | < |

| PL2-227A (ug/L) | | TREND & FMCL RELATION | |
|---|---|---|---|
| 8/7/13 | | | |
| PCE | 0.02 U | NT | < |
| TCE | 0.2 U | NT | < |
| cis 1,2 DCE | 0.2 U | NT | < |
| trans 1,2 DCE | 0.2 U | NT | < |
| VC | 0.2 U | NT | < |

KEY

SHEETPILE STRUCTURE
SHORELINE MONITORING WELL

| | | | |
|---|---|---|---|
| PCE | VINYL CHLORIDE | NT | NO TREND |
| TCE | TRICHLOROETHENE | DOWN | DOWNWARD TREND |
| cis 1,2 DCE | cis-1,2-DICHLOROETHENE | UP | UPWARD TREND |
| trans 1,2 DCE | trans-1,2-DICHLOROETHENE | < | MOST RECENT DATA BELOW FMCL |
| VC | TETRACHLOROETHENE | > | MOST RECENT DATA ABOVE FMCL |
| U | NON-DETECT | | |
| NA | NOT ANALYZED | | |
| FMCL | FINAL MEDIA CLEANUP LEVEL | | |

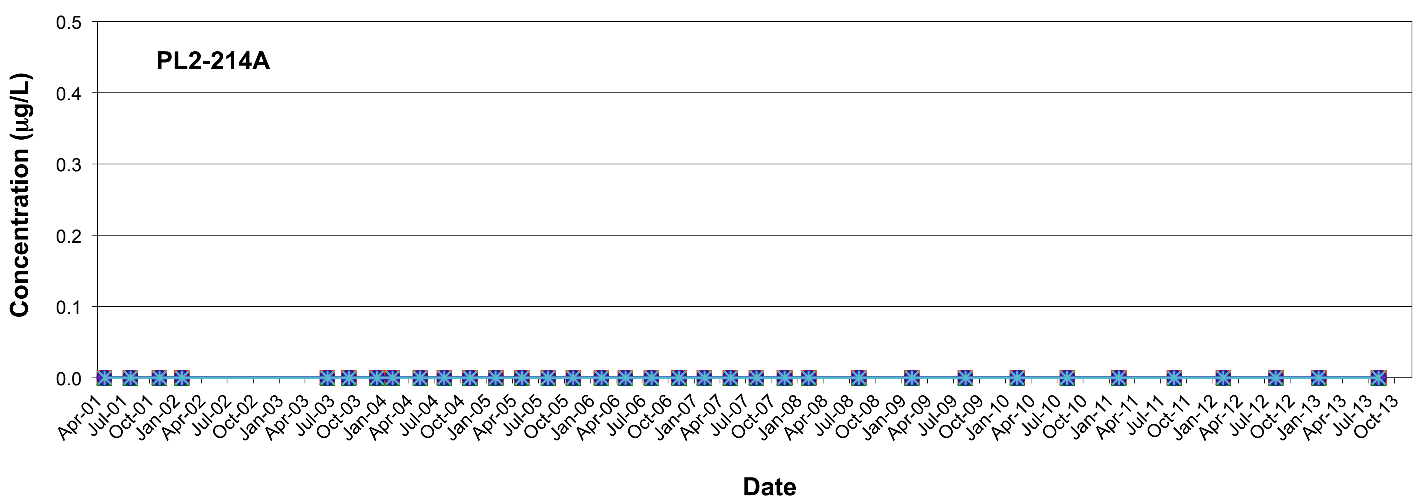
0 32.5 65 130
SCALE: 1" = 130'

ENVIRONMENTAL PARTNERS INC
295 NE Gilman Boulevard, Suite 201
Issaquah, Washington 98027

FIGURE 2-1a
AUGUST 2013 VOC RESULTS
SHORELINE MONITORING WELLS

| | |
|---|---|
| PROJECT | BOEING PLANT 2 |
| PREPARED FOR | THE BOEING COMPANY |
| LOCATION | 7725 EAST MARGINAL WAY SEATTLE/TUKWILA, WASHINGTON |

| PROJECT | DRAWN BY | REVIEWED BY | DATE |
|---|---|---|---|
| 17513.3 | MMH | DCK | 10/14/13 |




**Legend**

- cis-1,2-Dichloroethene
- trans-1,2-Dichloroethene
- Trichloroethene
- Vinyl Chloride
- Tetrachloroethene

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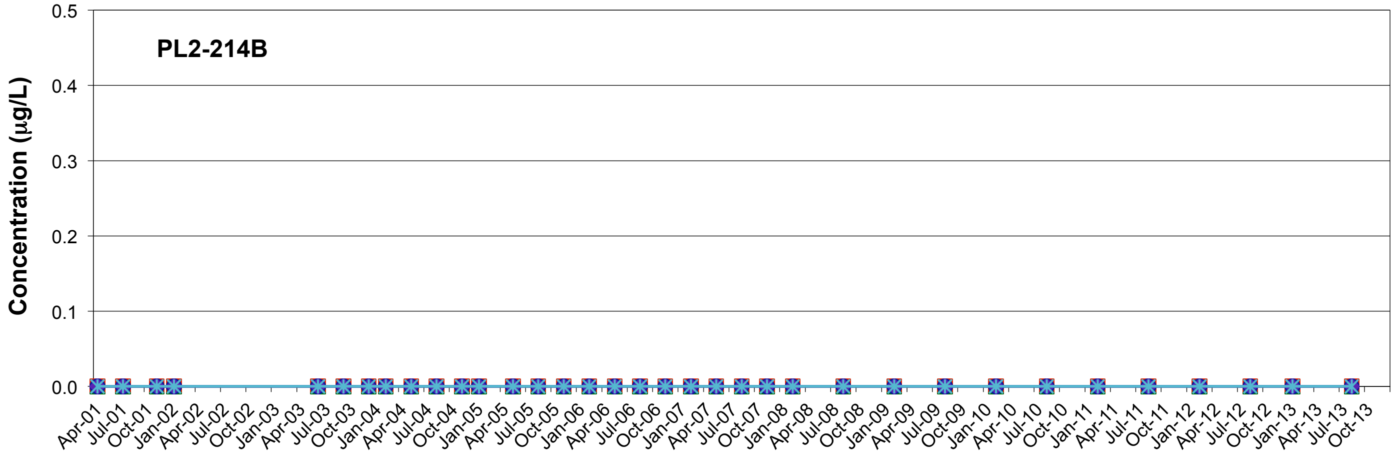
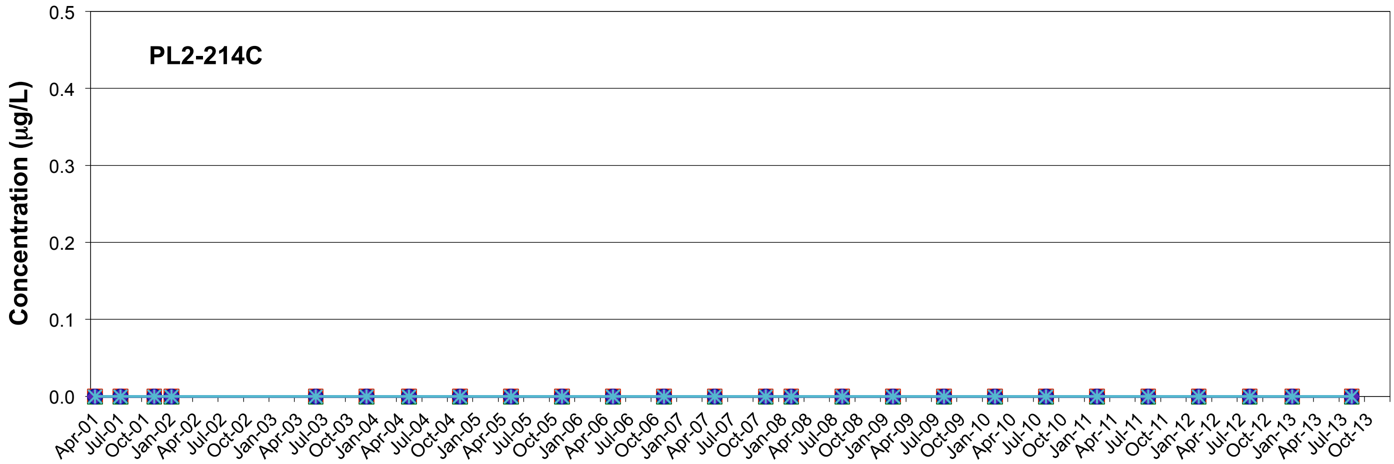
FIGURE 2-2d
CHLORINATED VOC TRENDS AT
PL2-043B, PL2-044B, AND PL2-214A

| | |
|---|---|
| Project | Boeing Plant 2 |
| Prepared For | The Boeing Company |
| Location | 7725 East Marginal Way<br>Seattle/Tukwila, Washington |

| Drawn By | Reviewed By | Date |
|---|---|---|
| DCK | DCK | 9/25/13 |




**Legend**

- cis-1,2-Dichloroethene
- trans-1,2-Dichloroethene
- Trichloroethene
- Vinyl Chloride
- Tetrachloroethene

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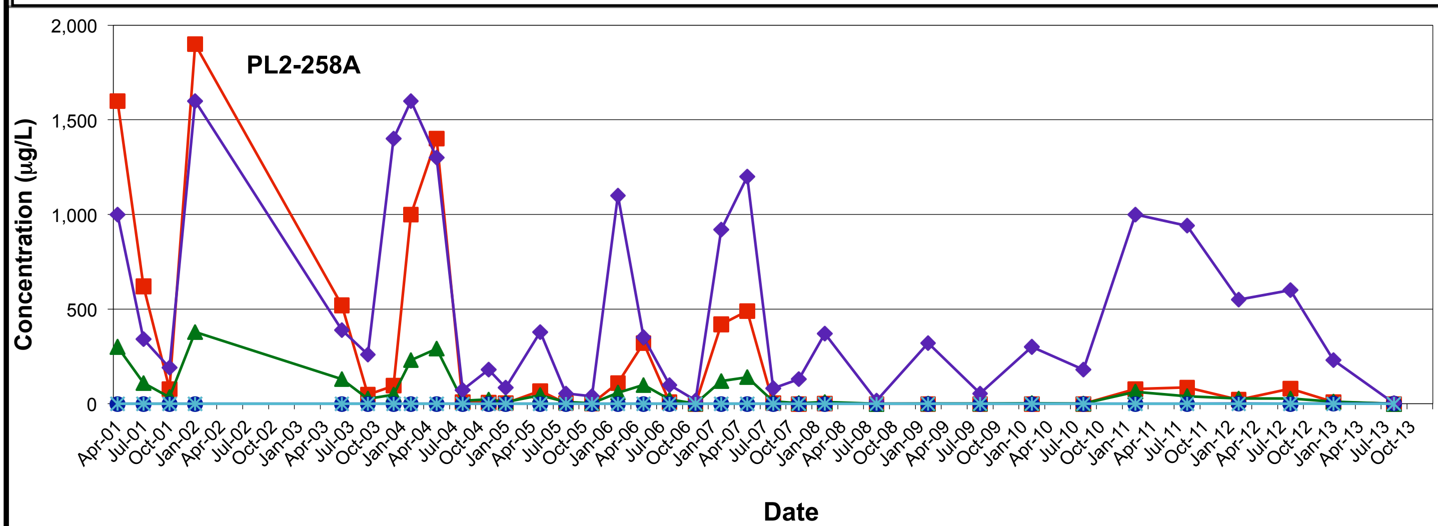
FIGURE 2-2e
CHLORINATED VOC TRENDS AT
PL2-214B, PL2-214C, AND PL2-227A

| | |
|---|---|
| Project | Boeing Plant 2 |
| Prepared For | The Boeing Company |
| Location | 7725 East Marginal Way<br>Seattle/Tukwila, Washington |

| Drawn By | Reviewed By | Date |
|---|---|---|
| DCK | DCK | 9/25/13 |




**Legend**

- cis-1,2-Dichloroethene
- trans-1,2-Dichloroethene
- Trichloroethene
- Vinyl Chloride
- Tetrachloroethene


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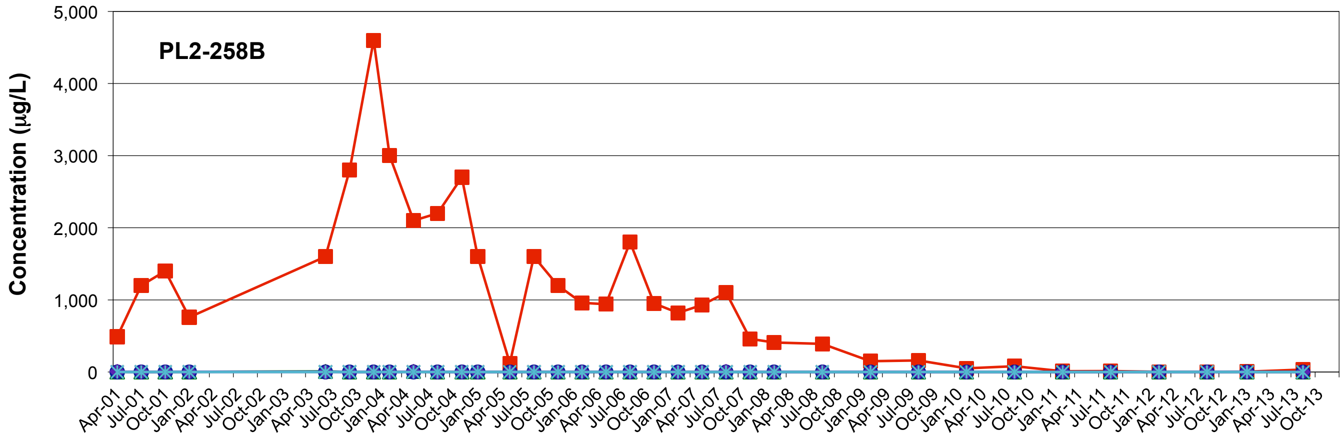
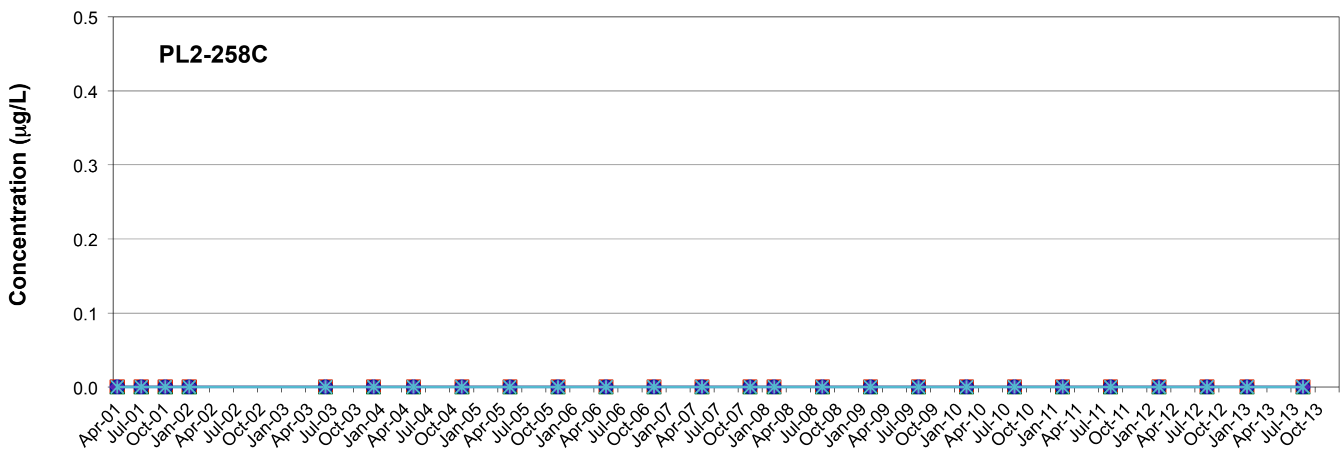
FIGURE 2-2f
CHLORINATED VOC TRENDS AT
PL2-232A, PL2-233A, AND PL2-258A

| | |
|---|---|
| Project | Boeing Plant 2 |
| Prepared For | The Boeing Company |
| Location | 7725 East Marginal Way<br>Seattle/Tukwila, Washington |

| Drawn By | Reviewed By | Date |
|---|---|---|
| DCK | DCK | 9/25/13 |




**Legend**

- cis-1,2-Dichloroethene
- trans-1,2-Dichloroethene
- Trichloroethene
- Vinyl Chloride
- Tetrachloroethene

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FIGURE 2-2g
CHLORINATED VOC TRENDS AT
PL2-258B, PL2-258C, AND PL2-271A

| | |
|---|---|
| Project | Boeing Plant 2 |
| Prepared For | The Boeing Company |
| Location | 7725 East Marginal Way<br>Seattle/Tukwila, Washington |

| Drawn By | Reviewed By | Date |
|---|---|---|
| DCK | DCK | 9/25/13 |

***Selected pages from:***

*Golder Associates, Inc. 2010. Uplands Corrective Measures Volume IX: 2-10 Area Data Gap Investigation Prepared for The Boeing Company Seattle, Washington. Prepared by Golder Associates Inc. Attachment E Report on Vapor Intrusion Sampling Building 2-10. May.*

**Table 3**
**Sample Collection Information**
**Vapor Intrusion Sampling in Building 2-10**
**Boeing Plant 2**

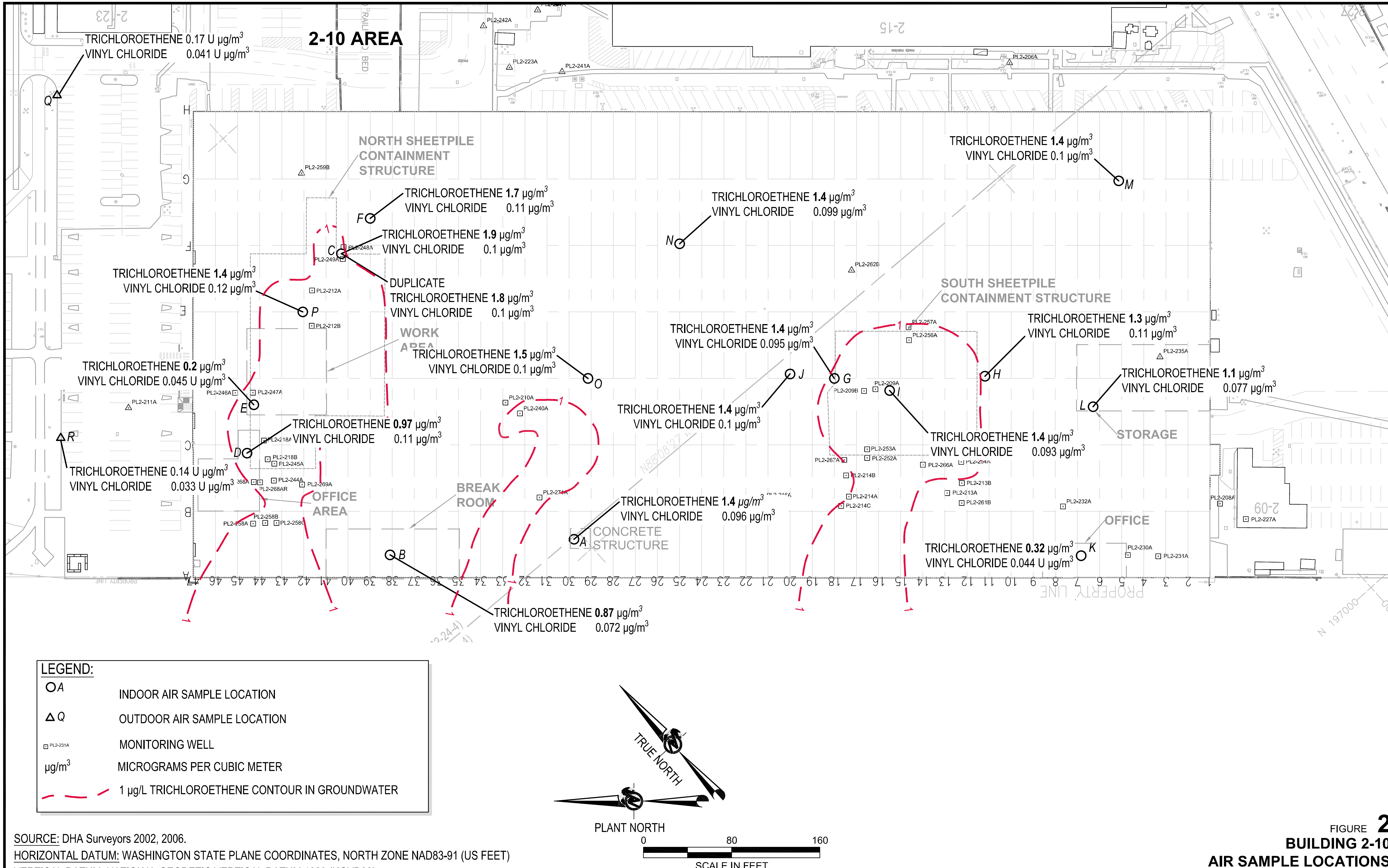
| Location ID | Sample ID | Sample Intake Height (inches) | Sample Start Time | Sample End Time | Initial Pressure (in Hg) | Final Pressure (in Hg) |
|---|---|---|---|---|---|---|
| A | PL2-210IA-A-122009 | 53.5 | 12:48 AM | 8:31 AM | -30 | -9 |
| B | PL2-210IA-B-122009 | 54 | 12:45 AM | 7:29 AM | -30 | -8 |
| C | PL2-210IA-C-122009 | 63 | 12:58 AM | 8:48 AM | < -30 | -7.5 |
| C | PL2-210IA-DUP-122009 | 63 | 12:58 AM | 8:48 AM | < -30 | -8.5 |
| D | PL2-210IA-D-122009 | 55.5 | 12:50 AM | 9:09 AM | -27.5 | -7.5 |
| E | PL2-210IA-E-122009 | 53.5 | 1:03 AM | 8:52 AM | < -30 | -8.5 |
| F | PL2-210IA-F-122009 | 55.75 | 1:00 AM | 8:35 AM | < -30 | -9 |
| G | PL2-210IA-G-122009 | 54.75 | 12:47 AM | 7:34 AM | < -30 | -8.5 |
| H | PL2-210IA-H-122009 | 54.25 | 12:45 AM | 8:34 AM | < -30 | -9 |
| I | PL2-210IA-I-122009 | 55.75 | 12:46 AM | 8:33 AM | < -30 | -8.5 |
| J | PL2-210IA-J-122009 | 56.5 | 12:48 AM | 8:58 AM | -29.5 | -9 |
| K | PL2-210IA-K-122009 | 55 | 12:43 AM | 8:38 AM | < -30 | -8.5 |
| L | PL2-210IA-L-122009 | 55.25 | 12:44 AM | 7:30 AM | < -30 | -8 |
| M | PL2-210IA-M-122009 | 55.5 | 12:53 AM | 7:37 AM | < -30 | -6 |
| N | PL2-210IA-N-122009 | 55 | 12:50 AM | 7:34 AM | < -30 | -8.5 |
| O | PL2-210IA-O-122009 | 55.5 | 12:58 AM | 8:57 AM | -27.5 | -8 |
| P | PL2-210IA-P-122009 | 55.5 | 12:56 AM | 8:35 AM | < -30 | -8 |
| Q | PL2-210IA-Q-122009 | 69.5 | 1:05 AM | 8:44 AM | < -30 | -7.5 |
| R[1] | PL2-210IA-R-122009 | 73.5 | 1:03 AM | 7:38 AM | < -30 | 0 |

Notes:
1. Canister found with no vacuum remaining at 5:16 am.

**Table 4**
**Air Sampling Analytical Results**
**Vapor Intrusion Sampling in Building 2-10**
**Boeing Plant 2**

| Sample Location | TO-15 SIM Analysis | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1,1-Dichloroethene | | Carbon Tetrachloride | | cis-1,2-Dichloroethene | | Tetrachloroethene | | Trichloroethene | | Vinyl Chloride | |
| | $ug/m^3$ | ppbv | $ug/m^3$ | ppbv | $ug/m^3$ | ppbv | $ug/m^3$ | ppbv | $ug/m^3$ | ppbv | $ug/m^3$ | ppbv |
| MTCA [3] | 500 | | 6.3 | | 87.5 | | 15.6 | | 3.7 | | 10.4 | |
| Building 2-10 Indoor Air | | | | | | | | | | | | |
| A | 0.068 U | 0.017 U | 0.42 | 0.068 | 0.14 U | 0.034 U | 0.23 U | 0.034 U | 1.4 | 0.27 | 0.096 | 0.038 |
| B | 0.076 U | 0.019 U | 0.42 | 0.067 | 0.15 U | 0.038 U | 0.26 U | 0.038 U | 0.87 | 0.16 | 0.072 | 0.028 |
| C | 0.071 U | 0.018 U | 0.4 | 0.063 | 0.14 U | 0.036 U | 0.24 U | 0.036 U | 1.9 | 0.35 | 0.1 | 0.039 |
| C (Duplicate) | 0.067 U | 0.017 U | 0.42 | 0.066 | 0.13 U | 0.034 U | 0.23 U | 0.034 U | 1.8 | 0.33 | 0.1 | 0.039 |
| D | 0.067 U | 0.017 U | 0.43 | 0.068 | 0.13 U | 0.034 U | 0.23 U | 0.034 U | 0.97 | 0.18 | 0.11 | 0.044 |
| E | 0.069 U | 0.018 U | 0.42 | 0.066 | 0.14 U | 0.035 U | 0.24 U | 0.035 U | 0.2 | 0.038 | 0.045 U | 0.018 U |
| F | 0.069 U | 0.018 U | 0.41 | 0.065 | 0.14 U | 0.035 U | 0.25 | 0.037 | 1.7 | 0.32 | 0.11 | 0.044 |
| G | 0.067 U | 0.017 U | 0.41 | 0.065 | 0.13 U | 0.034 U | 0.23 U | 0.034 U | 1.4 | 0.26 | 0.095 | 0.037 |
| H | 0.071 U | 0.018 U | 0.43 | 0.068 | 0.14 U | 0.036 U | 0.24 U | 0.036 U | 1.3 | 0.24 | 0.11 | 0.044 |
| I | 0.069 U | 0.018 U | 0.4 | 0.064 | 0.14 U | 0.035 U | 0.25 | 0.036 | 1.4 | 0.27 | 0.093 | 0.036 |
| J | 0.071 U | 0.018 U | 0.4 | 0.063 | 0.14 U | 0.036 U | 0.24 U | 0.036 U | 1.4 | 0.27 | 0.1 | 0.04 |
| K | 0.068 U | 0.017 U | 0.4 | 0.064 | 0.14 U | 0.034 U | 0.23 U | 0.034 U | 0.32 | 0.06 | 0.044 U | 0.017 U |
| L | 0.069 U | 0.018 U | 0.43 | 0.068 | 0.14 U | 0.035 U | 0.24 U | 0.035 U | 1.1 | 0.2 | 0.077 | 0.03 |
| M | 0.063 U | 0.016 U | 0.42 | 0.067 | 0.12 U | 0.032 U | 0.21 U | 0.032 U | 1.4 | 0.27 | 0.1 | 0.04 |
| N | 0.071 U | 0.018 U | 0.4 | 0.063 | 0.14 U | 0.036 U | 0.24 U | 0.036 U | 1.4 | 0.25 | 0.099 | 0.039 |
| O | 0.069 U | 0.018 U | 0.42 | 0.066 | 0.14 U | 0.035 U | 0.24 U | 0.035 U | 1.5 | 0.27 | 0.1 | 0.041 |
| P | 0.071 U | 0.018 U | 0.41 | 0.065 | 0.14 U | 0.036 U | 0.24 U | 0.036 U | 1.4 | 0.26 | 0.12 | 0.045 |
| Ambient Air Outside Building 2-10 | | | | | | | | | | | | |
| Q | 0.064 U | 0.016 U | 0.41 | 0.066 | 0.13 U | 0.032 U | 0.22 U | 0.032 U | 0.17 U | 0.032 U | 0.041 U | 0.016 U |
| R | 0.051 U | 0.013 U | 0.41 | 0.066 | 0.1 U | 0.026 U | 0.2 | 0.029 | 0.14 U | 0.026 U | 0.033 U | 0.013 U |

Notes:
1. $ug/m^3$ - micrograms per cubic meter
2. ppbv - parts per billion by volume
3. MTCA Method C indoor air concentrations provided by EPA in the March 2010 comment letter on the draft version of this report (EPA, 2010).
4. U - Not detected, value shown is reporting limit.




SOURCE: DHA Surveyors 2002, 2006.

HORIZONTAL DATUM: WASHINGTON STATE PLANE COORDINATES, NORTH ZONE NAD83-91 (US FEET)

VERTICAL DATUM: NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD29)

FIGURE 2

**BUILDING 2-10**
**AIR SAMPLE LOCATIONS**

Boeing/Plant 2 CMS Support/WA

K:\CAD\Projects\2001\0131646\x009\100\Task 07\013_1646_009_100_F02r2.dwg | Fig 2 | Mod: 02/17/2010, 11:51 | Plotted: 02/17/2010, 12:29 | ssimmons

Golder Associates

**Bacterial Census Count - February 2010**

*Source:*
*CALIBRE and Floyd|Snider. 2010. Interim Measure Work Plan for the North and South Sheetpiles in the 2-10 Building Area (AOC 2-10.3A and AOC 2-10.4A) Phase 2: IM Design and Implementation. Prepared for The Boeing Company. Prepared by CALIBRE Systems and Floyd|Snider, Bellevue, Washington. October.*

**Bacterial Census Count - February 2010**

| Sample Date | Location | DHE cells/mL |
|---|---|---|
| 2/9/2010 | PL2-209A | 72.2 |
| 2/9/2010 | PL2-212A | 1,580.0 |
| 2/9/2010 | PL2-218A | 86.7 |
| 2/9/2010 | PL2-218B | 73.8 |

Abbreviations:
DHE *Dehalococcoides spp.*
mL Milliliter

**Bacterial Census Count - November 2012**

*Source:*
*CALIBRE. 2013. Interim Status Report: Construction Summary and Remedial Optimization of 2-10 Interim Measures: Units AOC 2-10.3A and AOC 2-10.4A. Prepared for The Boeing Company. April 2013*

## Bacterial Census Count - November 2012

| | | PL2-212A | PL2-218A | PL2-218B | IW-N-4 | PL2-209A | IW-S-12 |
|---|---|---|---|---|---|---|---|
| Dehalococcoides spp. (DHE) | cells/mL | 6,660 | 3,420 | 73.8 | 644 | 653 | 79.6 |
| tceA Reductase | cells/mL | <4.3 | <1.3 | 72.7 | <45.5 | <1.5 | <9.1 |
| BAV1 Vinyl Chloride Reductase | cells/mL | 4,740 | 1,400 | 2.3 | 555 | 409 | 62.9 |
| Vinyl Chloride Reductase | cells/mL | 3 J | 124 | <0.5 | 48.4 | 4.9 | <9.1 |

Abbreviations:
DHE Dehalococcoides spp.
mL Milliliter
tceA Trichloroethene reductive dehalogenase

Qualifier:
J Estimated